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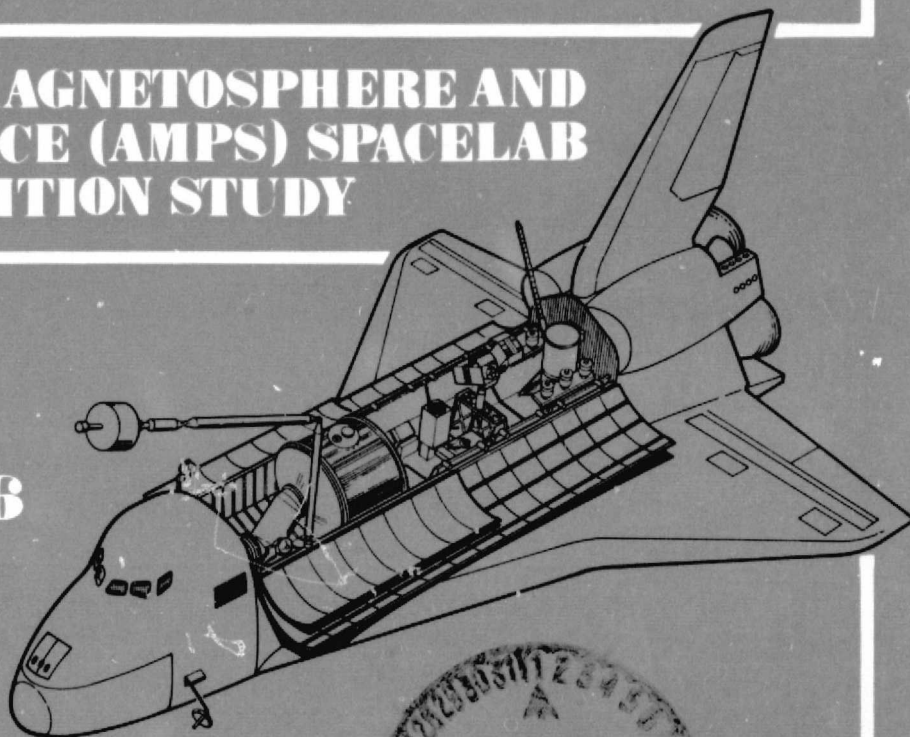
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ATMOSPHERE, MAGNETOSPHERE AND PLASMAS IN SPACE (AMPS) SPACELAB PAYLOAD DEFINITION STUDY

**Final Report
November 1976**



Prepared for
National Aeronautics
and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771



ATMOSPHERE, MAGNETOSPHERE AND PLASMAS IN SPACE (AMPS)
SPACELAB PAYLOAD DEFINITION STUDY
FINAL REPORT

VOLUME II
MISSION SUPPORT REQUIREMENTS DOCUMENT

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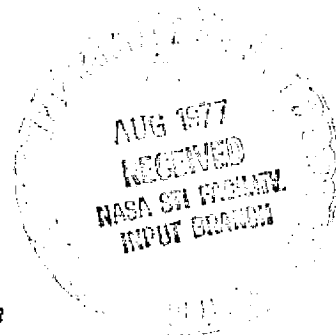
Approved by: W. F. Rector, III
W.F. Rector, III
Project Manager, AMPS

Prepared for
National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

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TRW
DEFENSE AND SPACE SYSTEMS GROUP

ONE SPACE PARK · REDONDO BEACH, CALIFORNIA 90278



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1. INTRODUCTION

- 1.1 PURPOSE. The purpose of the Mission Support Requirements Document (MSRD) is to define the flight payload, its operation, and the support required from the Space Transportation System (STS). The definition of the payload includes the flight objectives and requirements, the experiment operations, and the payload configuration. The support required from the STS includes the accommodation of the payload by the Orbiter/Spacelab, use of the flight operations network and ground facilities, and the use of the launch site facilities.
- 1.2 FLIGHT OBJECTIVES. The scientific objective of the AMPS program is to assist in developing a comprehensive understanding of the region surrounding the earth. Based on laboratory and space experimentation, several techniques for meeting this goal have been proposed. These techniques involve observing the effects produced by natural processes or by disturbances that are purposely imposed. Flight 1 experiments have been chosen that utilize these techniques and cover a broad range of investigations. The range of AMPS investigations has been apportioned into four disciplines — particle interactions, plasma interaction and flow, wave phenomena, and atmospheric science. Active experiments in each of these areas are included in the Flight 1 experiment list, as described below.
 - 1.2.1 The particle interaction discipline for Flight 1 is centered around experiments to be performed with an electron accelerator and its associated diagnostics. Three such investigations have been enumerated — vehicle neutralization, beam characteristics, and beam-plasma interactions. The primary objectives of the first two investigations are to study the properties of the electron beam and its effect on the vehicle. These studies will be crucial in deciding how experiments in this area can be carried on in future flights. The third investigation involves a study of how the electron beam interacts with the local plasma environment, and, as such, can be considered a second-generation experiment. The beam current capabilities, beam direction and stability, and general operating requirements will be determined in the first two experiments, and thereby determine the operating characteristics for the beam-plasma experiment.
 - 1.2.2 In the plasma interaction and flow category, a gas release system will provide the perturbing source for two investigations. The release and subsequent gas expulsion will be accomplished using five titanium canisters, each containing 50 kg of xenon. One investigation involves observing the early phases of the expansion as the gas cloud interacts with the ambient atmosphere. Rapid deceleration to a stationary state in less than 10 seconds and heating to 2000°K or more before dispersal and cooling are expected to occur. The second investigation depends on the release injecting enough energy through the Shuttle orbital velocity (~ 8 km/sec) into the upper atmosphere to create an observable acoustic gravity wave.

- 1.2.3 In the wave phenomena category, investigations on Flight 1 will be primarily directed at measuring the local EMI environment and determining the conditions under which the active probing experiments on future flights will be carried out. The environmental sensing package (ESP) will be instrumented with a variety of detectors for measuring the local dc magnetic field, as well as ac magnetic and electric fields to determine background EMI levels. Energetic particle and background plasma measurements will also be made with the ESP as it is moved throughout the rear Shuttle environment with the RMS.
- 1.2.4 Atmospheric investigations will be made in three areas. First, a hard-mounted lidar will be used to make ozone density measurements using a dual beam differential absorption technique. Second, an atmospheric array will perform limb scanning measurements to provide a worldwide map for a large number of molecular species in the upper atmosphere. Maps will be made of the molecular concentration and temperatures of chlorine oxide, nitric oxide, and the hydroxyl radical that are involved in the production and destruction of ozone. The third atmospheric measurements investigation will be performed with a solar flux monitor, used as a monitor to provide short time period calibration of solar instruments being flown on other spacecraft programs. Although this instrument is not strictly a part of the atmospheric measurements category, it is mounted in the same canister to be pointed by SIPS as the other atmospheric instruments.
- 1.2.5 In summary, a basic objective of all experiments on Flight 1 is to successfully perform investigations that will provide the groundwork for future missions. In each of the four investigation areas, even partial fulfillment of the objectives enumerated above can lead to very significant progress. The mission success criteria will be discussed in 1.4.
- 1.3 FLIGHT REQUIREMENTS. The flight objectives for the experiment disciplines were defined in 1.2. The requirements to meet those objectives are summarized here. The following sections define the requirements for the four disciplines - particle interactions, plasma interaction and flow, wave phenomena, and atmospheric science.
- 1.3.1 The particle interaction experiments require direct optical viewing of the beam profile, thus demanding operation in darkness. For safety as well as experimental reasons, the beam must be aligned closely with respect to the local magnetic field direction. Careful monitoring of possible potential buildup of the Orbiter during accelerator operation is necessary.

- 1.3.2 The plasma interaction and flow experiments require the gas canister ignition over the Arecibo, Puerto Rico, ground radar scatter facility during local darkness. The canister will be released and placed into an orbit that locates it behind the Shuttle. This will allow on-board viewing of the initial expansion phase with the optical instrument complement.
- 1.3.3 The wave phenomena measurements performed with the ESP-mounted instruments are to be performed under all conditions possible, both to study natural environmental effects, and to seek out possible superior operating conditions for other experiments. As such, these measurements are to be made night and day, early and late in the flight, at all altitudes and latitudes encountered during the flight, and in all Orbiter orientations with respect to the magnetic field and velocity vector.
- 1.3.4 Ozone measurements require the lidar to be used in the downward viewing mode, pointing to within 10 degrees of the nadir. The ozone measurements can be performed at any time, and will in fact best be carried out by using a variety of geographic locations. Initial test firings, however, would best be performed in the dark to minimize any problems with background radiation.
- 1.3.5 The atmospheric minor constituents experiments require scanning the earth's limb, but can be performed at any time so long as the sun is not in the field of view. The solar flux monitor will view the sun's disk once per day at local noon. Since the limb scanning instruments are also mounted on the SIPS, these must be shut down and closed off during this period of time. The solar viewing is best performed at the flight's maximum altitude (to minimize atmospheric absorption) and during periods of minimum outgassing and effluents release.
- 1.4 **SUCCESS CRITERIA.** The success of the flight is based on the achievement of specific events within each of the four investigation areas. These events are given a category rating. The investigations will be considered a success if each of Category 1 events are achieved during the flight.

<u>Investigation Area</u>	<u>Category</u>
Particle interactions	
Produce an observable beam at one-half power or current	(TBD)
Produce beam at full power and current	(TBD)
Observe Shuttle neutralization behavior	(TBD)
Observe beam stability	(TBD)
Observe beam-plasma interaction	(TBD)

Investigation AreaCategory

Chemical release

Produce at least one observable release (TBD)

For each additional release (TBD)

Produce usable data on one expansion (TBD)

Observe one gravity wave generation (TBD)

Produce usable data on each additional expansion (TBD)

Observe additional gravity waves (TBD)

Wave phenomena (environmental measurements)

Mapping electromagnetic radiation (TBD)

Mapping pressure and composition (TBD)

Mapping ion, electron densities and temperatures (TBD)

Determination of surface contaminations (TBD)

Determination of magnetic and electrostatic background (TBD)

Atmospheric science

Send and receive lidar signal (TBD)

Complete lidar soundings (TBD)

Successfully cool IR instruments (TBD)

Perform a series of limb scans and obtain interferometer data (TBD)

Complete limb scans (TBD)

Perform solar flux monitor experiments (TBD)

- 1.5 APPLICABLE DOCUMENTS. The following documents form a part of this document. The date and issue are shown unless the document is under CCB control. In this case, "current issue" is shown in place of the specific date and issue.

<u>Item No.</u>	<u>Title</u>	<u>Date</u>
1.	NASA/ESA Memorandum of Understanding, NASA-SL-MU-8-73	14 Aug 73
2.	Spacelab Programme Plan, NASA-MF-74-2	26 Sep 74
3.	Program Requirements Document-Level I, NASA-MF-74-1	Revision 2
4.	Spacelab Systems Requirements Document, SLP/2100	Current issue
5.	Spacelab Operations Requirements-Overview - Vol. I (Preliminary) SL-OP-030	Preliminary
6.	Spacelab Operations Requirements - Ground Operations - Vol. II (Preliminary) SL-OP-031	Preliminary
7.	Spacelab Operations Requirements - Mission Operations - Vol. III (Preliminary)	Preliminary
8.	Spacelab Operations Requirements - Logistics Operations - Vol. IV (Preliminary) SL-OP-033	Preliminary
9.	Space Shuttle Program Flight and Ground Systems Specification, JSC 07700, Vol. X	Current issue
10.	Space Shuttle Program System Payload Accom- modations, Vol. XIV	Current issue
11.	Spacelab Payload Accommodation Handbook, ESTEC SLP/2104	Current issue

2. EXPERIMENT OPERATIONS

During the first flight of the AMPS payload, nine experiments will be performed in order to study the atmosphere and magnetosphere and to investigate plasma phenomena in the ionosphere. The following is a list of the experiments:

- (1) Vehicle neutralization
- (2) Beam characteristics
- (3) Beam-plasma interactions
- (4) Acoustic gravity waves
- (5) Gas cloud expansion dynamics
- (6) Minor constituents
- (7) Ozone density
- (8) Environmental measurements
- (9) Solar radiation

Experiments (1), (2), and (3) are basically similar in that they use the electron accelerator. Experiments (4) and (5) are performed simultaneously on the same gas cloud release [(4) deals with the interactions close to the center of the release and (5) deals with the traveling waves produced by the release]. Experiment (8) will be used to provide data for future AMPS flights and should be performed as often as possible during the mission. Experiment (9) will be performed for 30 minutes near local noon six times during the flight. Experiment (6) uses the infrared interferometer to do limb scanning of atmospheric emissions. Experiment (7) uses the lidar to make differential absorption measurements of atmospheric ozone. The experiment operations have been enumerated in 2.1 through 2.4. In 2.1 appears the listing of experiment operation sequences for each of the nine experiments. These sequences represent short summary descriptions of the actual step-by-step procedures required to perform the experiments. In 2.2, the experiment orbital constraints and requirements are listed in tabular form by referring back to the procedural step defined in 2.1. In 2.3 and 2.4, the experiment operational constraints and requirements and the instrument operational constraints and requirements are listed, again in tabular form, and again referring back to the steps enumerated in 2.1.

- 2.1 EXPERIMENT SEQUENCE DEFINITIONS. The following lists of steps involved in the carrying out of each of the experiments for Flight 1 have been broken down into broad groupings of steps rather than into detailed, individual operations. The final list of detailed operations will depend on the exact instrument and subsystem designs as well as the specifics of the controls, displays, and software arrangements.

2.1.1 Vehicle neutralization

- (1.1) Check accelerator supplies. Check monitor housekeeping of energy storage bank, low voltage power processor; begin charging of bank and monitor until bank is fully charged.
- (1.2) Check accelerator. Ready cathode for use, check high voltage processor; check electron optics, beam bending coils and all housekeeping monitors.
- (1.3) Orient Orbiter. Orient with Orbiter Z-axis pointed along the local magnetic field line, upwards. Hold orientation through remainder of experiment.
- (1.4) Check diagnostics. Turn on Level 2 diagnostic instruments and check for proper functioning.
- (1.5) Ready accelerator for firing. Set in beam characteristics desired, energy, current, pulse shape, firing time and duration. Ready Level 1 diagnostics if desired. Set bending coils.
- (1.6) Fire accelerator. Initiate firing sequence.
- (1.7) Collect data. Data to be collected from Level 2 diagnostics, accelerator monitors, Level 1 diagnostics (if used) for a period of at least 1 minute before firing to 1 minute after firing in order to determine the spacecraft charging characteristics during the beam emission period.
- (1.8) Repeat. The whole procedure, (1.1) through (1.7), would be repeated for various beam characteristics, various Shuttle orientations, various local times, altitudes, and geographic positions in order to gather enough data to determine the vehicle neutralization characteristics for any firing conditions.
- (1.9) Shut down. Turn off diagnostic instruments; put accelerator into a standby or off mode; cover accelerator if necessary; discharge energy storage banks and short them. Release Orbiter attitude for other experiments.

2.1.2 Beam characteristics

- (2.1) Check accelerator supplies. Same as (1.1)
- (2.2) Check accelerator. Same as (1.2)
- (2.3) Orient Orbiter. Same as (1.3)

- (2.4) Check diagnostics. Turn on Level 2 diagnostics, OBIPS, the following ESP instruments: E&B receivers, medium energy electron detector, magnetometer, Langmuir probe and ion mass and distribution analyzer. Check each of them for proper operation.
- (2.5) Orient ESP. Put the RMS into the desired position so that ESP will be able to make the desired measurements of the beam.
- (2.6) Ready accelerator for firing. Same as (1.5)
- (2.7) Fire accelerator. Same as (1.6)
- (2.8) Collect data. Data to be collected from Level 1 and 2 diagnostics and the ESP instruments for at least 1 minute before and after the firing in order to ascertain what the characteristics of the electron beam are after it leaves the aperture of the accelerator. It is necessary to compare the characteristics of the traveling electron beam to those determined by reference to the monitor functions of the accelerator itself.
- (2.9) Repeat. Repeat (2.1) through (2.8) at various accelerator energy, current and focusing settings so that the characteristics of the beam can be calibrated for future use by reference to the accelerator settings only.
- (2.10) Shut down. Same as (1.9) plus release RMS for other experiments.

2.1.3 Beam-plasma interactions

- (3.1) Check accelerator supplies. Same as (1.1)
- (3.2) Check accelerator. Same as (1.2)
- (3.3) Orient Shuttle. Same as (1.3)
- (3.4) Check diagnostics. Same as (2.4)
- (3.5) Orient ESP. Put the RMS into the desired position or scan mode so that ESP will be able to measure the beam-plasma interaction.
- (3.6) Ready accelerator for firing. Same as (1.5)
- (3.7) Fire accelerator. Same as (1.6)
- (3.8) Collect data. Data to be collected from Level 1 and 2 diagnostics, and the ESP instruments for at least 1 minute before and after the firing in order to ascertain the interaction of the beam with the ambient plasma.

(3.9) Repeat. Repeat (3.1) through (3.8) at various accelerator energies, currents and focusing settings; various RMS positions, various Orbiter attitudes, beam pitch angles, Orbiter geographic locations, and local times.

(3.10) Shut down. Same as (2.10).

2.1.4 Acoustic gravity waves and gas cloud expansion dynamics

These investigations have exactly the same steps as far as in-orbit operations.

(4.1) Check release canister. Make sure that the xenon canister is in working order and ready for ejection from the Orbiter.

(4.2) Orient Orbiter for ejection of canister. The canister will be spring ejected into the proper orbit so that when the canister is fired the Orbiter will be in a proper position to view the expanding gas cloud.

(4.3) Check diagnostic instruments. Turn on the OBIPS and the IR interferometer and make sure that they are properly functioning.

(4.4) Orient Orbiter. Orient the Orbiter so that when the xenon canister is fired the gas cloud will be from 1 to 10 km directly behind the Orbiter and so that the SIPS will be able to view the expanding cloud.

(4.5) Orient SIPS. Put SIPS into mode where it will be able to view the expanding cloud as long as the cloud is above the horizon.

(4.6) Fire xenon gas release canister. Initiate the gas release.

(4.7) Take data. Take data from the OBIPS and the IR interferometer for as long as the gas cloud remains above the horizon.

(4.8) Shut down. Turn off OBIPS and IR interferometer, calibrate if possible, release SIPS and Orbiter for other experiments.

2.1.5 Minor constituents

(5.1) Cool IR system. Begin the cooling process of the cryogenically cooled IR telescope and the IR detectors.

(5.2) Check IR system. Once system is cold, turn on IR detectors and check all monitor functions. Do sample or calibration runs of the IR interferometer and check the data output for accuracy.

- (5.3) Orient Orbiter. Put the Orbiter into an attitude where the SIPS will be able to do limb scanning of the earth's atmosphere over the altitude range from 20 to 100 km.
- (5.4) Orient SIPS. Put the SIPS into an earth limb scanning mode.
- (5.5) Take data. Turn the IR interferometer on and let it take limb scan data for long periods of time in order to build up a map of the various atmospheric emissions.
- (5.6) Examine data. Periodically look at the data output from the IR interferometer in order to check its qualitative accuracy and monitor the housekeeping functions of both the SIPS and the interferometer for proper operations.
- (5.7) Shut down. Turn off IR interferometer, calibrate if possible, release SIPS and Orbiter for other experiments. Cooling to the telescope optics should be maintained.

2.1.6 Ozone density

- (6.1) Check lidar system. Start dye pump, charge capacitor bank, align and tune lasers, check all housekeeping monitors, turn on receiver detector, check receiver alignment. Calibrate if possible.
- (6.2) Orient Orbiter. Orient Orbiter so that laser can fire toward the nadir within 10 degrees and hold this orientation throughout the remainder of the experiment.
- (6.3) Test fire lasers. Fire lidar into atmosphere and check firing systems, receiver output, laser outputs, alignments, power consumption, laser and receiver tunings.
- (6.4) Do lidar soundings. Begin firing lidar on automatic mode for DIAL ozone measurements once per second; i.e., two laser firings per second.
- (6.5) Examine data. Periodically check to see that the data being collected by the lidar system has the proper qualitative features.
- (6.6) Shut down. Turn lidar system off, calibrate if possible, check all monitor functions for proper operation. Release Orbiter for other experiments.

2.1.7 Environmental measurements

- (7.1) Check ESP instruments. Turn on E&B receivers, medium energy electron detector, Langmuir probe, neutral mass spectrometer, ion mass and distribution analyzer, dc electric field meter. Calibrate as necessary, check all monitor functions for proper operation, extend antennas as possible.
- (7.2) Check microbalance. Turn on quartz crystal microbalance, calibrate, check monitors for proper functioning.
- (7.3) Position ESP. Put RMS into environmental scanning mode, either preprogrammed or periodic movements from one position to another manually.
- (7.4) Take data. Whenever possible while other operations are being performed, the ESP should be making survey measurements of the Orbiter environment. Orbiter orientation should vary during these measurements so that the environment of the Orbiter wake can be examined in all aspects. The point of the experiment is to gather as much data as possible for as many different operating modes of the entire AMPS payload, Spacelab, and Orbiter.
- (7.5) Shut down. Turn instruments off, calibrate if possible. Quartz crystal microbalance remains on for entire flight. Release RMS and ESP package for other experiments.

2.1.8 Solar radiation

- (8.1) Check solar flux instrument. Turn instrument on, check performance and housekeeping monitors. If there is a calibration cycle, perform it.
- (8.2) Orient Orbiter. Orient the Orbiter so that the SIPS will be able to view the sun. The orientation is to be held during the remainder of the experiment.
- (8.3) Orient SIPS. Put the SIPS into a mode whereby it will allow the solar flux instrument to center on the sun for the remainder of the experiment.
- (8.4) Take data. Turn solar flux instrument on for a period long enough to collect 30 minutes worth of data when the sun is within 45 degrees of the zenith. The data can either be stored or transmitted to the ground directly. There would be little crew interaction with the experiment once it has started.
- (8.5) Shut down. Turn instrument off, release SIPS for other experiments, release Orbiter orientation for other experiments. Run some checks on the quality of data obtained during the observation period.

2.2 EXPERIMENT ORBITAL CONSTRAINTS AND REQUIREMENTS

Step No.	Instruments Used	Orbit Inclination	Altitude	Attitude	Time of Day	Time into Flight	Geographic Position
	Vehicle neutralization						
(1.1)	Power processor energy storage bank	N/A	N/A	N/A	N/A	N/A	N/A
(1.2)	Accelerator	N/A	N/A	N/A	N/A	about 12 hrs or more for outgassing	N/A
(1.3)	Orbiter and magnetometer	57°	150	Fixed with regard to magnetic field	N/A	>12 hrs	N/A
(1.4)	Level 2 diagnostics	N/A	150	N/A	night	>12 hrs	N/A
(1.5)	Accelerator	N/A	150	Fixed with regard to magnetic field	night	>12 hrs	N/A
(1.6)	Accelerator	57°	150	Fixed with regard to magnetic field	night	>12 hrs	N/A
(1.7)	Levels 1 and 2	57°	150	Fixed with regard to magnetic field	night	>12 hrs	N/A
(1.8)	Same as (1.7)						
(1.9)	Same as (1.1)						
	Beam characteristics						
(2.1)	Same as (1.1)						
(2.2)	Same as (1.2)						
(2.3)	Same as (1.3)						
(2.4)	Levels 1 and 2 E and B receiver e-analyzer Langmuir probe Ion analyzer Magnetometer RMS	N/A	150	Fixed with regard to magnetic field	N/A	>12 hrs	N/A
(2.5)	RMS	N/A	N/A	N/A	N/A	N/A	N/A
(2.6)	Same as (1.5)						
(2.7)	Same as (1.6)						

Step No.	Instruments Used	Orbit Inclination	Altitude	Attitude	Time of Day	Time into Flight	Geographic Position
(2.8)	Levels 1 and 2 E and B receiver e-analyzer Langmuir probe Ion analyzer Magnetometer RMS	57°	150	Fixed with regard to magnetic field	Night	>12 hrs	N/A
(2.9)	Same as (2.7) and (2.8)						
(2.10)	Same as (2.7)						
	Beam plasma interactions and gas cloud dynamics						
	(3.1) through (3.10) are essentially the same as (2.1) through (2.10) in same order.						
	Acoustic gravity wave						
(4.1)	Chemical release	N/A	N/A	N/A	N/A	N/A	N/A
(4.2)	Orbiter	57°	200	As necessary for release over Arecibo			
(4.3)	OBIPS and IR interferometer	N/A	N/A	N/A	Night	N/A	N/A
(4.4)	Orbiter	57°	200	Z-axis anti- parallel to velocity	Night	N/A	Before Arecibo overpass
(4.5)	SIPS	Same as 2.1.4.4					
(4.6)	Chemical release	57°	200	N/A	Night	As necessary	Over Arecibo 1 to 10 km from Orbiter
(4.7)	OBIPS and IR interferometer	57°	200	Looking backwards at gas cloud	Night	As necessary	Over Arecibo until cloud over horizon behind
(4.8)	All above	N/A	N/A	N/A	N/A	N/A	N/A
	Minor constituents						
(5.1)	IR interferometer	N/A	150	N/A	N/A	12 hrs	N/A

Step No.	Instruments Used	Orbit Inclination	Altitude	Attitude	Time of Day	Time into Flight	Geographic Position
(5.2)	IR interferometer	57°	150	Z-axis	Night	>12 hrs	N/A
(5.3)	Orbiter	57°	150	away from earth	Any	>12 hrs	N/A
(5.4)	SIPS	----- Same as (5.3) -----					
(5.5)	IR interferometer SIPS	57°	150	So that SIPS can do limb scans	Any	>12 hrs	Any
(5.6)	Same as (5.5)						
(5.7)	Orbiter, SIPS IR interferometer	N/A	N/A	N/A	N/A	N/A	N/A
	Ozone density						
(6.1)	Lidar	N/A	N/A	N/A	N/A	N/A	N/A
(6.2)	Orbiter	57°	250	Z nadir	N/A	N/A	N/A
(6.3)	Lidar	57°	250	Z nadir	Night	N/A	N/A
(6.4)	Lidar	57°	250	Z nadir	Any	N/A	Any
(6.5)	Same as (6.4)						
(6.6)	Lidar, Orbiter	N/A	N/A	N/A	N/A	N/A	N/A
	Environment measurements						
(7.1)	All ESP instruments	N/A	150	N/A	Night	>12 hrs	N/A
(7.2)	Microbalance	N/A	N/A	N/A	N/A	As soon as possible	N/A
(7.3)	RMS	N/A	N/A	N/A	N/A	N/A	N/A
(7.4)	All ESP instruments Microbalance	Any	Any	Any	Any	Any	Any
(7.5)	All ESP instruments Microbalance	N/A	N/A	N/A	N/A	N/A	N/A
	Solar radiation						
(8.1)	Solar flux monitor	N/A	N/A	N/A	N/A	N/A	N/A
(8.2)	Orbiter	57°	150	So SIPS can point at sun	N/A	N/A	N/A
(8.3)	SIPS	57°	150	At sun	Near local noon	N/A	N/A
(8.4)	SIPS, solar flux monitor	57°	150	SIPS pointed at sun	With 15 min of local noon	N/A	N/A
(8.5)	SIPS, solar flux monitor	N/A	N/A	N/A	N/A	N/A	N/A

2.3 EXPERIMENT OPERATIONS CONSTRAINTS AND REQUIREMENTS

Step No.	Instruments Used	Magnetic Position	Pointing Direction	Crew and Skills	Ground Operations	Data (bps)
	Vehicle neutralization					
(1.1)	Power processor energy storage bank	N/A	N/A	1 accelerator specialist	Monitor charging	120
(1.2)	Accelerator	N/A	N/A	1 accelerometer specialist	Monitor checkout	47,440
(1.3)	Orbiter, Magnetometer	Z-axis along B upwards	To fire beam up mag- netic field line	Orbiter crew	Monitor maneuver	TBD
(1.4)	Level 2 diagnostics	N/A	Diagnostics out of wake up B field line	1 scientist	Monitor checkout	351,280
(1.5)	Accelerator	Z on B up	Up B field line	2 scientists	Verify setup	47,440
(1.6)	Accelerator	Z on B up	Up B field line	1 scientist	Possible coordination with ground operations	47,440
(1.7)	Level 1 and 2	Z on B up	Up B field line	1 scientist	Monitor data	398,720
(1.8)	Same as (1.1) through (1.7)					
(1.9)	Accelerator, Level 1, 2, energy storage, processor, Orbiter	N/A	N/A	1 scientist Orbiter crew	N/A	N/A
	Beam characteristics					
(2.1)	Same as (1.1)	Z on B up	Up B field	2 scientists	Monitor checkout	
(2.2)	Same as (1.2)					
(2.3)	Same as (1.3)					
(2.4)	Level 1 and 2 diagnostics E and B receivers e-analyzer Langmuir probe Ion analyzer Magnetometer RMS					351,383
			Three axis			5,900
			At various, angles			5,290
			Perpendicular to B and V			2,720
			Along V			5,664
			Three axis			728
			Various			TBD

Step No.	Instruments Used	Magnetic Position	Pointing Direction	Crew and Skills	Ground Operations	Data (bps)
(2.5)	RMS	Z on B up	Various	1 mission specialist	Some decisions	TBD
(2.6)	Same as (1.5)					
(2.7)	Same as (1.6)					
(2.8)	as per (2.4)	Z on B up	Various for diagnostics Up B field for accelerator	2 scientists	Monitor data	419,125
(2.9)	Same as (2.1) through (2.8)					
(2.10)	All instruments	N/A	N/A	2 scientists, mission specialist	N/A	N/A
	Beam plasma interactions					
(3.1) through (3.10) are essentially the same as (2.1) through (2.10), in same order						
	Acoustic gravity wave and gas cloud expansion dynamics					
(4.1)	Chemical release module	N/A	N/A	1 technician	N/A	204
(4.2)	Orbiter	N/A	As necessary for proper ejection	Orbiter crew	Close coordination with ground station	TBD
(4.3)	OBIPS and IR interferometer	N/A	N/A	1 scientist	Monitor checkout	2,521,942 4.2 MHz
(4.4)	Orbiter	N/A	As necessary for canister ejection	Orbiter crew	Coordination backup calculations	TBD
(4.5)	SIPS	N/A	In the anti-velocity direction	1 technician	N/A	TBD
(4.6)	Chemical release canister	N/A	N/A	1 mission specialist	Must coordinate with ground station	204
(4.7)	SIPS, OBIPS, IR Int.	N/A	Anti-velocity and then track cloud over horizon	2 scientists	Monitor data	2,521,942 4.2 MHz
(4.8)	as above	N/A	N/A	2 scientists, technician Orbiter crew	N/A	N/A

Step No.	Instruments Used	Magnetic Position	Pointing Direction	Crew and Skills	Ground Operations	Data (bps)
	Minor constituents					
(5.1)	IR interferometer	N/A	N/A	1 technician	Monitor checkout	224
(5.2)	IR interferometer	N/A	N/A	2 scientists, technician	Monitor checkout	2,511,942
(5.3)	Orbiter	N/A	So that SIPS can do limb scans	Orbiter crew	Monitor and backup calculations	TBD
(5.4)	SIPS	N/A	At the limb doing scans 20 to 100 km altitude	1 technician	Monitor and backup calculations	TBD
(5.5)	IR interferometer SIPS	N/A	At the limb doing scans 20 to 100 km altitude	2 scientists, technician periodic	Full time monitor Full time calculations	2,511,942 plus SIPS TBD
(5.6)	Same as (5.5)					
(5.7)	IR interferometer SIPS, Orbiter	N/A	N/A	1 technician	N/A	N/A
	Ozone density					
(6.1)	Lidar	N/A	N/A	2 scientists, technician	Monitor checkout	872
(6.2)	Orbiter	N/A	Within 4° of nadir with Z-axis	Orbiter crew	N/A	TBD
(6.3)	Lidar	N/A	Laser beam fired toward nadir	2 scientists, technician	Monitor setup	4,072
(6.4)	Lidar	N/A	Within 4° of nadir	2 scientists, technician periodic	Full time monitor of data perhaps realtime map	4,072
(6.5)	Same as (6.4)					
(6.6)	Lidar, Orbiter	N/A	N/A	1 technician	N/A	N/A

Step No.	Instruments Used	Magnetic Position	Pointing Direction	Crew and Skills	Ground Operations	Data (bps)
	Environment measurements					
(7.1)	E and B receivers e-analyzer Langmuir probe Ion analyzer Magnetometer Neutral Mass Spectrometer DC E-field	N/A Various N/A N/A N/A N/A N/A	Antennas must be clear away from Orbiter Perpendicular to B and V Parallel to V Into velocity vectrometer N/A	1 technician 1 technician 1 technician 1 technician 1 technician 1 technician 1 technician	Monitor checkout Monitor checkout Monitor checkout Monitor checkout Monitor checkout Monitor checkout Monitor checkout	5,900 5,290 2,720 5,664 728 5,680 1,032
(7.2)	Microbalance	N/A	N/A	1 technician	Monitor checkout	640
(7.3)	RMS	Various	Various	1 mission specialist	Keep track of positions	TBD
(7.4)	all instruments	Various	Various	2 scientists, technician periodic	Monitor data full time and perhaps do map plots	27,654 plus RMS TBD
(7.5)	all instruments	N/A	N/A	1 technician	N/A	N/A
	Solar radiation					
(8.1)	Solar flux monitor	N/A	N/A	1 technician	Monitor checkout	3,200
(8.2)	Orbiter	N/A	So that SIPS can see sun	Orbiter crew	Monitor	TBD
(8.3)	SIPS	N/A	At sun	1 technician	Monitor pointing	TBD
(8.4)	Solar flux, SIPS	N/A	At sun	1 technician	Monitor data	3,200 plus SIPS TBD
(8.5)	Solar flux, SIPS Orbiter	N/A	N/A	1 technician	N/A	N/A

2.4 INSTRUMENT OPERATIONAL CONSTRAINTS

Step No.	Instruments Used	Safety, Mechanical and Electrical Limitations	Temperature Range (°C)	Pressure Range (torr)	Coordination with Other Operational Steps
Vehicle neutralization					
(1.1)	Power processor I Energy storage bank	Not to exceed max charging rates or max energy	-30 to 50 5 to 70	N/A Sealed	Unit should be charged only before use
(1.2)	Accelerator	No cathode overheat, voltage limits, current limits	-30 to 50	$<5 \times 10^{-5}$	None
(1.3)	Orbiter, Magnetometer	Z-axis never perpendicular to magnetic field	N/A	N/A	N/A
(1.4)	Level 2	No over voltages on grids	-30 to 50	$<5 \times 10^{-5}$	None
(1.5)	Accelerator	No fire beam 70° to magnetic field	-30 to 50	$<5 \times 10^{-5}$	Charging complete
(1.6)	Accelerator	Same as (1.5)	-30 to 50	$<5 \times 10^{-5}$	Automatic firing sequence
(1.7)	Level 1 and 2	Avoid beam on sensitive elements	-30 to 50	$<5 \times 10^{-5}$	during 2.1.1.6
(1.8)	Same as (1.1) through (1.7)				
(1.9)	Same as (1.1) through (1.7)				
Beam neutralization					
(2.1)	Same as (1.1)	No over voltages on grids Careful extension of antennas High voltage arcing possible No over voltages No over voltages ----- No interference with Orbiter or payload	-30 to 50	$<5 \times 10^{-5}$	None
(2.2)	Same as (1.2)		-30 to 50	Any	
(2.3)	Same as (1.3)		-30 to 50	$<5 \times 10^{-5}$	
(2.4)	Level 1 and 2 E and B receiver e-analyzer Langmuir probe Ion analyzer Magnetometer RMS		-30 to 50	$<5 \times 10^{-5}$	
			-30 to 50	Any	
			TBD	Any	
(2.5)	RMS	No interference with Orbiter or payload Diagnostics not in main beam	TBD	Any	May move during firing
(2.6)	Same as (1.5)	Avoid high beam currents on sensitive elements	-30 to 50	$<5 \times 10^{-5}$	1 min before and 1 min after 2.1.2.7
(2.7)	Same as (1.6)				
(2.8)	Same as (2.4)				
(2.9)	Same as (2.1) through (2.8)				
(2.10)	Same as (2.1) through (2.8)				

Step No.	Instruments Used	Safety, Mechanical and Electrical Limitations	Temperature Range (°C)	Pressure Range (torr)	Coordination with Other Operational Steps
	Beam plasma interactions				
(3.1) through (3.10) are essentially the same as (2.1) through (2.10), taken in the same order					
	Acoustic gravity wave and gas cloud expansion dynamics				
(4.1)	Chemical release module	There will be a safing mechanism to prevent release while on-board	-30 to 50	Any	None
(4.2)	Orbiter	Ejection must not hit shuttle	N/A	N/A	This step may occur hours before remainder of experiment
(4.3)	OBIPS IR interferometer	Night operation Must be cooled, open only at night	5 to 35 cryo cooled	Any $<5 \times 10^{-5}$	None
(4.4)	Orbiter	N/A	N/A	N/A	None
(4.5)	SIPS	No point sun, no hit payload	TBD	Any	2.1.4.3 instruments on
(4.6)	Chemical release canister	At least 1 km from Orbiter in dark	-30 to 50	low	
(4.7)	OBIPS IR interferometer	No light overload No light overload	5 to 35 cryo cooled	$<5 \times 10^{-5}$	Done simultaneously with 2.1.4.6
(4.8)	Same as (4.1) through (4.7)				
	Minor constituents				
(5.1)	IR interferometer	Slow cooling no pressure buildup, never open if pointed at sun	down to -263	$<5 \times 10^{-5}$	
(5.2)	Same as (5.1)				
(5.3)	Orbiter	Never look at sun	N/A	Any	Must hold for long time
(5.4)	SIPS	Never look at sun, no hit payload	TBD	Any	
(5.5)	SIPS IR interferometer	Same as 2.1.6.4 Same as 2.1.6.1	TBD cryo cooled	Any $<5 \times 10^{-5}$	Long period may do 2.1.7 steps at same time
(5.6)	Same as (5.5)				
(5.7)	Same as (5.1) through (5.6)				
	Ozone density				
(6.1)	Lidar	No overcharge capacitors, watch heat dissipation closely, laser beam not hit anything	5 to 50	Any	

Step No.	Instruments Used	Safety, Mechanical and Electrical Limitations	Temperature Range (°C)	Pressure Range (torr)	Coordination with Other Operational Steps
(6.2)	Orbiter	Altitude not too low, laser eye danger	N/A	N/A	Should be consistent with (1.6) steps
(6.3)	Same as (6.1)				
(6.4)	Same as (6.1)				
(6.5)	Same as (6.1)				
(6.6)	Same as (6.1)				
	Environment measurements				
(7.1)	ESP E and B receivers e-analyzer Langmuir probe Neutral mass Ion analyzer Magnetometer DC electric field	Limited power available, no hit payload Care with antennas High voltage arcing possible Contamination possible Contamination possible Contamination possible Overload field possible Same as E and B receivers	All -30 to 50	All $< 5 \times 10^{-5}$	Operates at all times during entire flight
(7.2)	Microbalance	Heat limit	Any	Any	
(7.3)	RMS	No payload interference	TBD	Any	
(7.4)	Same as (7.1) through (7.3)				
(7.5)	Same as (7.1) through (7.3)				
	Solar radiation				
(8.1)	Solar flux monitor	Care not to overload detector	-30 to 50	$< 5 \times 10^{-5}$	None No other steps
(8.2)	Orbiter	No other optical instrument on	N/A	Any	
(8.3)	SIPS	Other instruments in SIPS open to sun	TBD	Any	
(8.4)	Same as (8.1)				
(8.5)	Same as (8.1) through (8.4)				

3. PAYLOAD CONFIGURATION

The Flight 1 Payload shall be configured in accordance with the following sections.

- 3.1 PAYLOAD MANIFEST AND PHYSICAL PROPERTIES. See Table III.I-1 for the Flight 1 manifest and physical properties. On Table III.I-2, the mass properties are summarized. The center of gravity estimates are covered on Figure 3.1-1.

Table III.I-1. AMPS Flight 1 Payload Manifest

EQUIPMENT LOCATION <u>Orbiter Aft Flight Deck</u>											CENTER OF GRAVITY			
APPLICABLE SERIAL NUMBER	QUANTITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	X	Y	Z
(To be supplied) ↓	1	Keyboard assembly			X						5	(To be supplied) ↓		
	1	Data display unit			X						30			
	1	High rate digital recorder			X						47			
	1	C&W and safing panel	X											
	1	Documentation camera	X											
	1	Safing cmd J-Box	X											
	1	C&W J-box	X											
	1	C&W signal cable	X											
	1	Safing signal cable	X											
	1	C&W signal cable	X											
	1	Safing signal cable	X											
	1	C&W and safing power cable	X											
		Subtotals												

Table III.I-1. AMPS Flight 1 Payload Manifest (Continued)

EQUIPMENT LOCATION <u>Spacelab Module</u>											CENTER OF GRAVITY			
APPLICABLE SERIAL NUMBER	QUANTITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	X	Y	Z
(To be supplied) ↓	2	Single rack			X						78	(To be supplied) ↓		
	2	Double rack			X						124			
	4	Experiment switch panel			X						16			
	1	Experiment computer			X						33			
	1	Experiment I/O unit			X						33			
	5	Experiment RAU			X						49			
	2	Keyboard assembly			X						10			
	2	Data display unit			X						60			
	1	High rate multiplexer			X						25			
	4	Stowage container ceiling			X						29			
	4	Rails console vertical			X						5			
	3	Rack foot restraint			X						3			
	1	Intercom remote station			X						1			
	1	Voice digitizer			X						1			
	1	SIPS control panel	X											

Table III.I-1. AMPS Flight 1 Payload Manifest (Continued)

Table III.I-1. AMPS Flight 1 Payload Manifest (Continued)														
EQUIPMENT LOCATION <u>Spacelab Module (Continued)</u>											CENTER OF GRAVITY			
APPLICABLE SERIAL NUMBER	QUAN- TITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB PAYLOAD SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	X	Y	Z
(To be supplied ↓	1	QBIPS control panel	X									(To be supplied ↓		
	1	Lidar control panel, Type 1	X											
	1	Lidar control panel, Type 2	X											
	1	Accelerator control panel	X											
	1	Magnetometer mast control panel		X										
	1	Accelerator digital interface unit	X											
	1	Video and display recorder	X											
	1	Payload C&W panel		X										
	1	C&W J-box		X										
	1	Safing command J-box		X										
	1	Quartz crystal microbalance controller		X										
	1	Lidar control cable		X										
	1	OBIPS control cable		X										
	1	SIPS control cable		X										

Table III.I-1. AMPS Flight 1 Payload Manifest (Continued)

EQUIPMENT LOCATION <u>Spacelab Module (Continued)</u>											CENTER OF GRAVITY			
APPLICABLE SERIAL NUMBER	QUANTITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION SUPPORT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	X	Y	Z
(To be supplied) ↓	3	HRM coax cable		X							(To be supplied) ↓			
	4	QCM cable		X										
	1	Accelerator cable		X										
	3	Caution and warning cable		X										
	3	Safing command cable		X										
	2	EPDB/ESP power cable		X										
	6	ESP/control panel cable		X										
	4	Safing panel/control cable		X										
	3	Certified flight tape					X							
	1	Flight data file, see Table III.IX-1						X						
		Subtotals												

[illegible]

Table III.I-1: AMPS Flight 1 Payload Manifest (Continued)

EQUIPMENT LOCATION Pallet No. 1

APPLICABLE SERIAL NUMBER	QUAN- TITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION SUPPORT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	CENTER OF GRAVITY		
												X	Y	Z
(To be supplied)	1	Experiment inverter 400 Hz			X						(To be supplied)			
	1	ESP functional assembly (ESP Type 1)		X										
	1	Electron accelerator	X											
	1	Common energy storage device		X										
	1	EPDB - experiment			X									
	1	RAU - experiment			X									
	1	C&W J-box		X										
	1	Labcraft emergency safing unit		X										
	1	SIPS control cable		X										
	1	OBIPS control cable		X										
	1	Lidar control cable		X										
	1	Accelerator control cable		X										
	1	HRM coax cable		X										
	1	C&W cable		X										

Table III.I-1. AMPS Flight 1 Payload Manifest (Continued)

EQUIPMENT LOCATION <u>Pallet No. 1 (Continued)</u>			INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	CENTER OF GRAVITY		
APPLICABLE SERIAL NUMBER	QUANTITY	NAME OR DESCRIPTION										X	Y	Z
(To be supplied) ↓	1	C&W cable, transit		X							(To be supplied)			
	2	Safing command cable		X										
	1	Safing command cable		X										
	1	HRM coax cable, transit		X										
	3	Standard power cable		X										
	3	Standard C&W cable		X										
	4	Type 1 standard RAU cable		X										
	2	Type 2 standard RAU cable		X										
	200	Standard cable clamp, pallet		X										
	1	Thermal blanket set, electron accelerator		X										
	1	Thermal blanket set, ESP functional assembly		X										
1	Thermal blanket set, common energy storage		X											
1	Thermal blanket set, EPDB				X									

Table III.I-1. AMPS Flight 1 Payload Manifest (Continued)

EQUIPMENT LOCATION <u>Pallet No. 1 (Continued)</u>			INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT MISSION SUPPORT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	CENTER OF GRAVITY		
APPLICABLE SERIAL NUMBER	QUANTITY	NAME OR DESCRIPTION											X	Y	Z
(To be supplied)		Thermal blanket clamps		X								(To be supplied)			
	2	Cold plate				X									
	16	Cold plate, standoff				X									
	1	Freon line system				X									
		Pallet hardpoints				X									
	1	Accelerator adapter		X											
	1	Accelerator adapter mounting hardware set		X											
	1	Accelerator mounting hardware set		X											
	1	Functional assembly mounting hardware set		X											
	1	Common energy storage mounting hardware set		X											
	1	EPDB (experiment) mounting hardware set			X										
	1	RAU (experiment) mounting hardware set		X											

Table III.1-1. AMPS Flight 1 Payload Manifest (Continued)

EQUIPMENT LOCATION Pallet No. 1 (Continued)

[illegible]

EQUIPMENT LOCATION Pallet No. 2

[illegible]

Table III.I-1. AMPS Flight 1 Payload Manifest (Continued)

Table III.I-1. AMPS Flight 1 Payload Manifest (Continued)														
EQUIPMENT LOCATION			Pallet No. 3											
APPLICABLE SERIAL NUMBER	QUAN- TITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	CENTER OF GRAVITY		
												X	Y	Z
		(To be supplied) ↓												
		Subtotal												

Table III.I-2. Mass Properties Summary

	Launch Mass (kg)	Landing Mass (kg)
Pallet segment No. 1	783	729
Pallet segment No. 2	1,446	1,357
Pallet segment No. 3	1,477	937
Module	290	290
Aft flight deck	80	80
Total payload mass	4,076	3,443
Mission-dependent equipment	736	736
Baseline Spacelab equipment	7,562	7,162
Payload specialist	210	210
Total payload mass	12,583	11,550

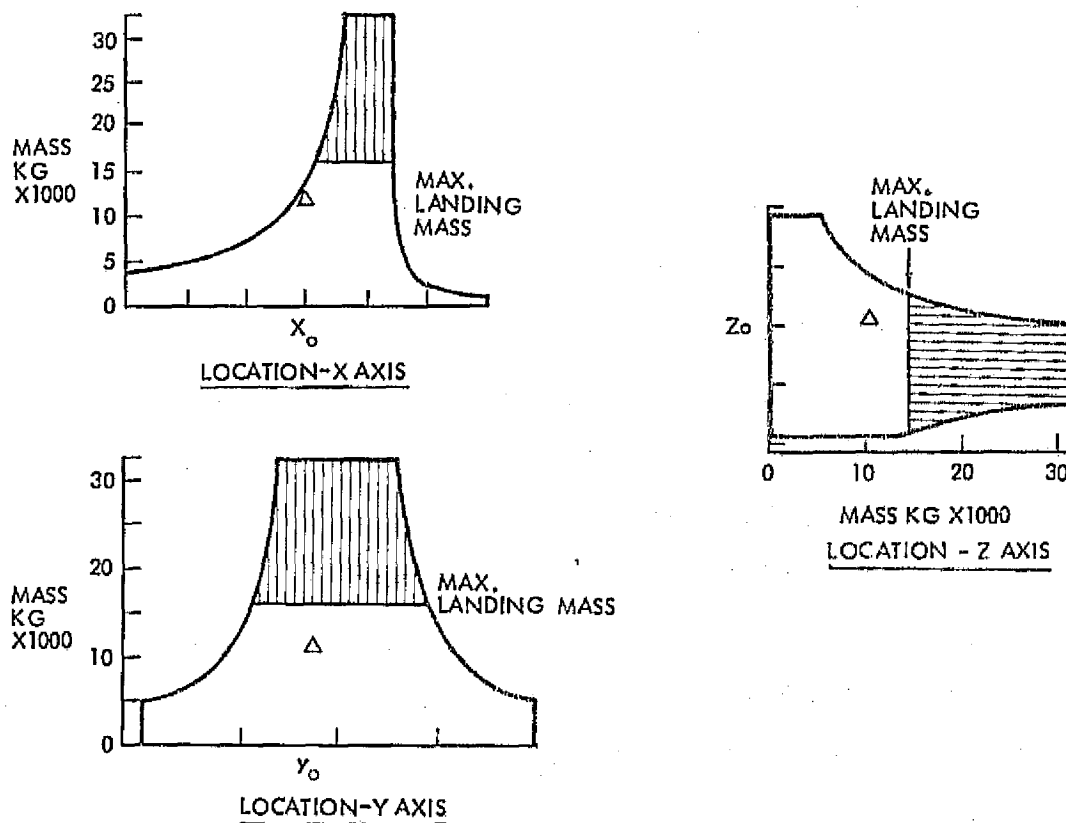


Figure 3.1-1. Flight 1 Center of Gravity Estimates

3.2 PAYLOAD LAYOUTS. The AMPS Flight 1 Payload layouts are given on the following figures:

Figure 3.2-1. OAFD Payload Layout (TBS)

Figure 3.2-2. Spacelab Module Controls and Displays Layout

Figure 3.2-3. Pallet Layout

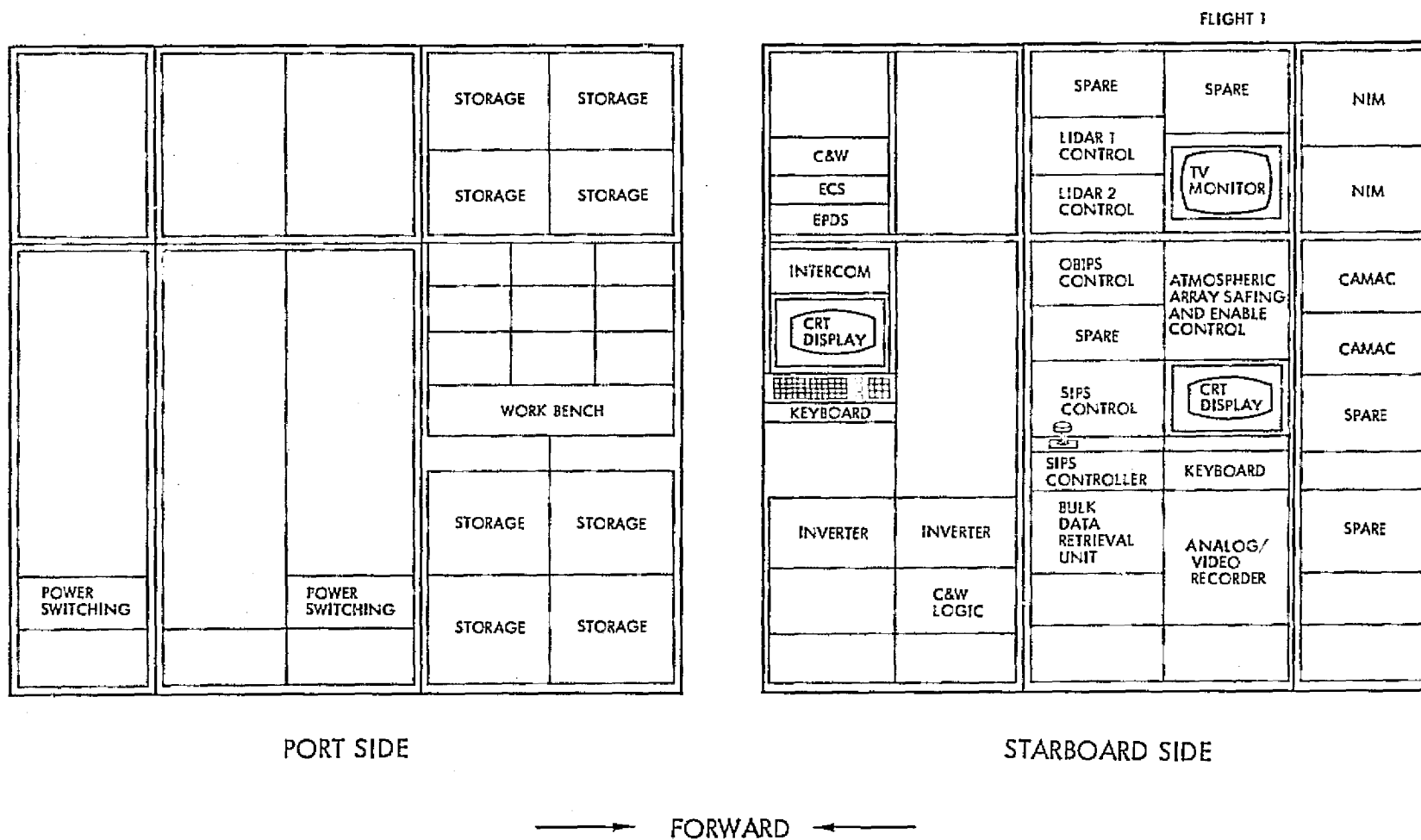
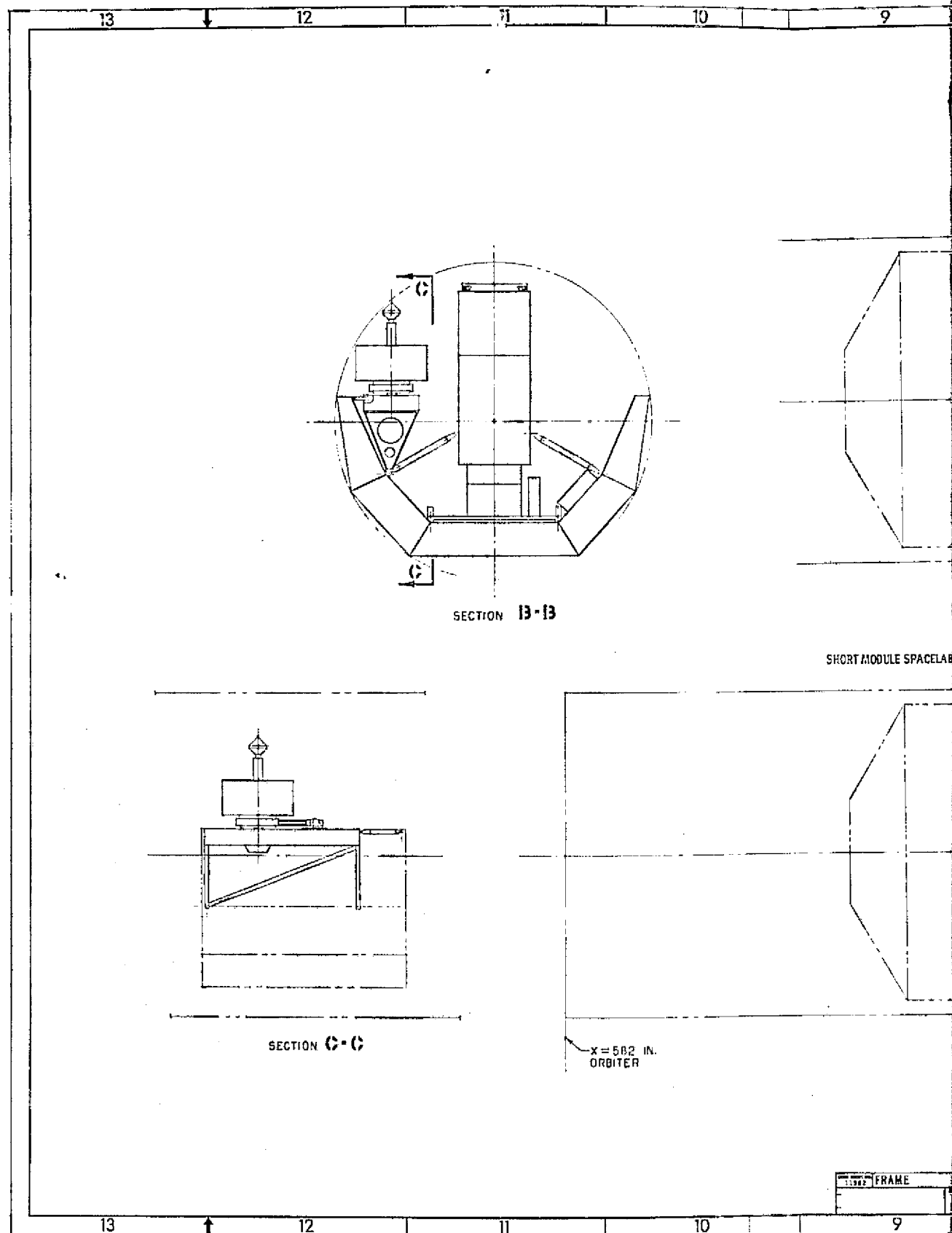
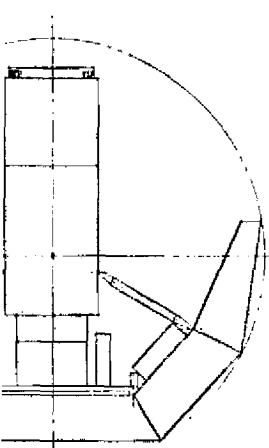
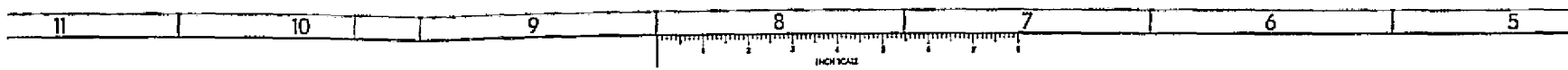


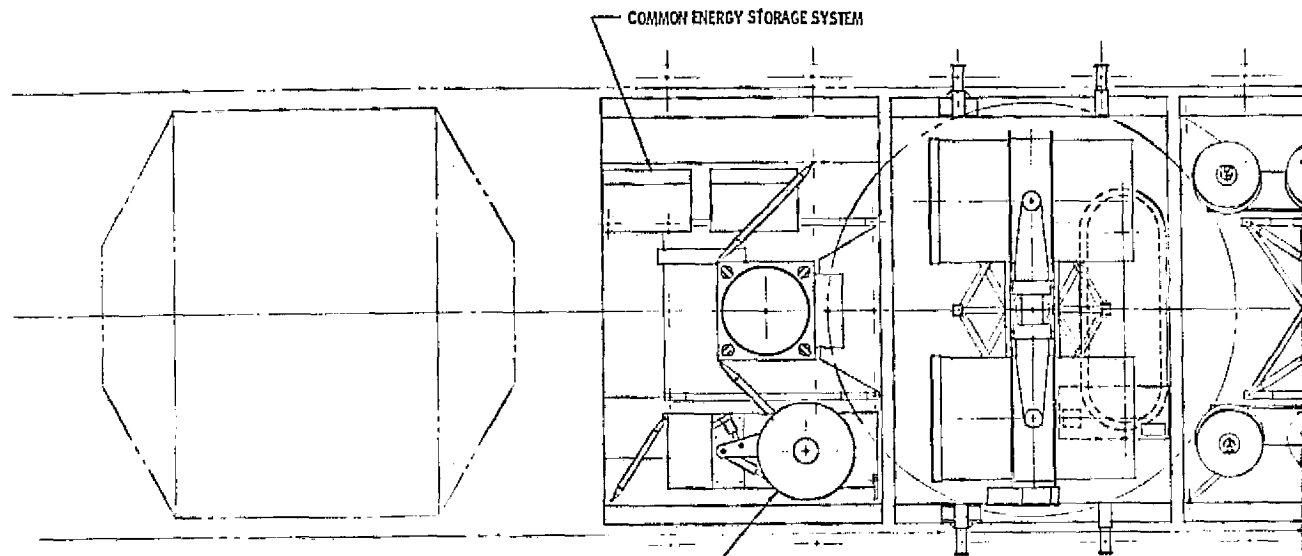
Figure 3.2-2. SpaceLab Module Controls and Displays Layout



FOLDOUT FRAME



SECTION 13-13



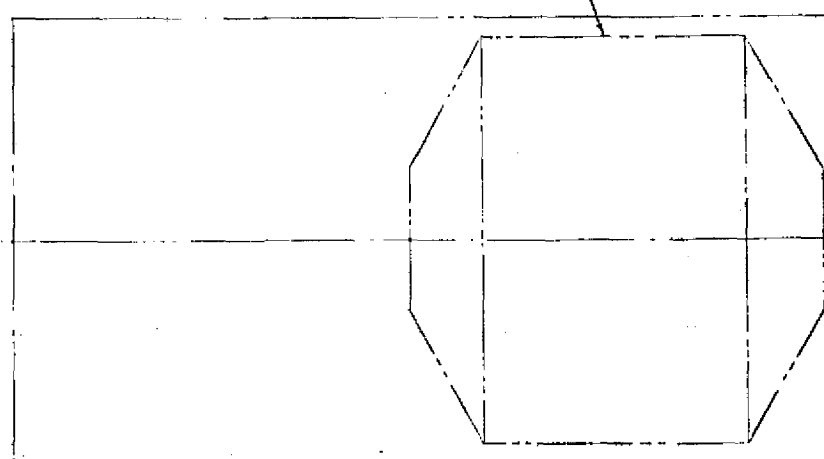
COMMON ENERGY STORAGE SYSTEM

ENVIRONMENTAL SENSING PACKAGE

SIPS POINTING CONTROL SYSTEM WITH ATMOSPHERIC INSTRUMENT CLUSTER

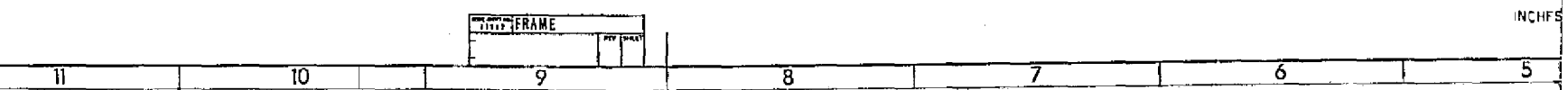
ACCELERATOR SYSTEM

SHORT MODULE SPACELAB



X = 582 IN. ORBITER

MAXIMUM PAYLOAD ENVELOPE



FOLDOUT FRAME	
REV	DATE
1	10/1/71

FOLDOUT FRAME 2

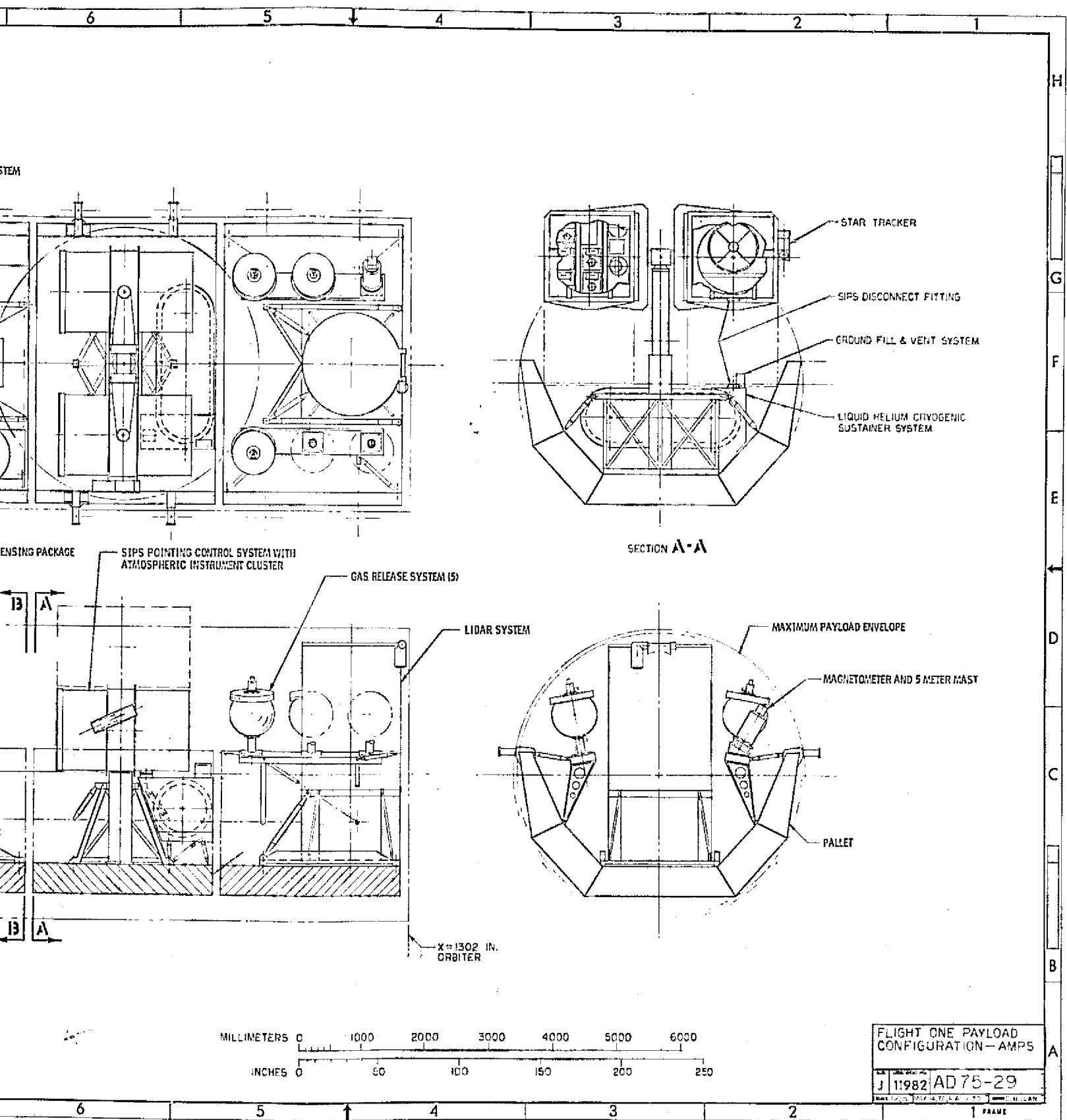
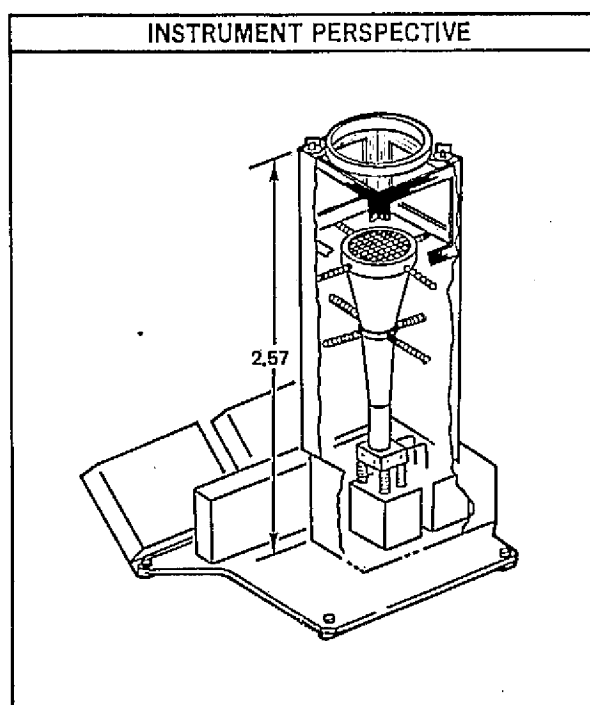


Figure 3.2-3. Pallet Layout

FOLDOUT FRAME 3

3.3 INSTRUMENT DESCRIPTIONS. This section contains a description of the Flight 1 instruments and other experiment apparatus. It includes pallet-mounted equipment, boom-mounted equipment, and equipment contained within the Environmental Sensing Package (ESP).

3.3.1 Electron accelerator. Design to produce a uniform beam of electrons with energies from a few hundred electron volts up to 40 kilo-electron volts at currents from zero to 2 amperes. A magnetic deflection system is provided in order to control the injection pitch angle. The maximum beam power will be 40 kilowatts.



MASS PROPERTIES		
LAUNCH WT. =	328	KG
LANDING WT. =	328	KG
I_x =	TBD	KG-M ²
I_y =	TBD	KG-M ²
I_z =	TBD	KG-M ²

ELECTRICAL POWER		
TYPE	28 VDC	
STANDBY	200	WATTS
OPERATING	2378	WATTS
TOTAL ENERGY		KWH

THERMAL CHARACTERISTICS		
MAX. EXT. TEMP.		°K
POWER DISSIPATION		
CONDUCTED		WATTS
RADIATED		WATTS
TOTAL		WATTS

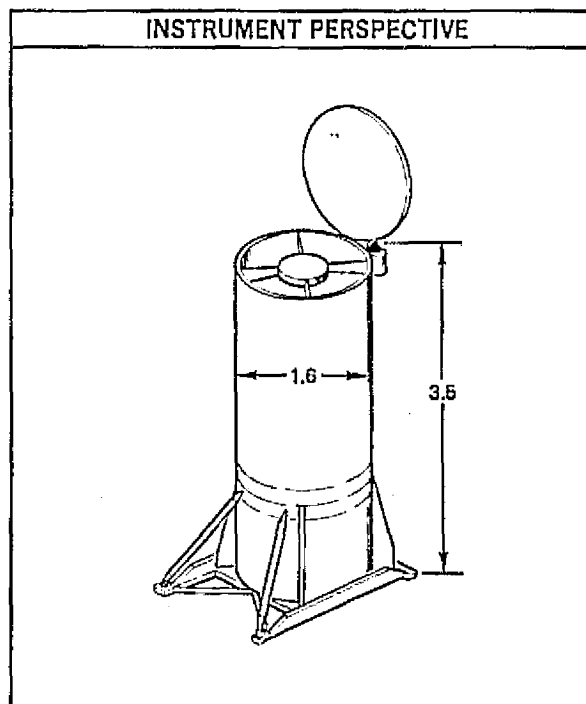
EQUIPMENT HAZARDS

OPERATING CHARACTERISTICS	
CONTROL	(MANUAL OR AUTOMATIC)
DUTY CYCLE	
DATA RATE	49.4 KBPS
OPERATING TIME	TOTAL
CREW TASKS	
FIELD OF VIEW	70° Half Cone
MODES	
COMMANDS	

WIRING SCHEMATIC

- OPERATING SEQUENCE DESCRIPTION
- SPECIAL SUPPORT REQUIREMENTS
- CALIBRATION REQUIREMENTS:
 - PRE-LAUNCH
 - FLIGHT
 - POST-FLIGHT

- 3.3.2 Lidar. The system consists of two lasers operating at near ultraviolet wavelengths, each emitting one pulse per second at one joule per pulse, and a collecting optics telescope of 1 square meter area. The lasers will be flash pumped, dye lasers. The lidar will have a special purpose processor to give altitude resolved reflection coefficients.



MASS PROPERTIES		
LAUNCH WT. =	779	KG
LANDING WT. =	779	KG
I_x =	TBD	KG-M ²
I_y =	TBD	KG-M ²
I_z =	TBD	KG-M ²

ELECTRICAL POWER		
TYPE	28 VDC	
STANDBY	40	WATTS
OPERATING	2054	WATTS
TOTAL ENERGY		KWH

THERMAL CHARACTERISTICS		
MAX. EXT. TEMP.		°K
POWER DISSIPATION		
CONDUCTED		WATTS
RADIATED		WATTS
TOTAL		WATTS

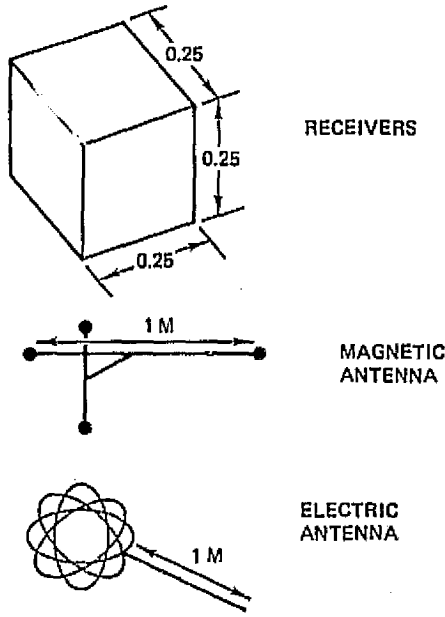
EQUIPMENT HAZARDS

OPERATING CHARACTERISTICS
CONTROL (MANUAL OR AUTOMATIC)
DUTY CYCLE
DATA RATE 4.1 Kbps
OPERATING TIME TOTAL
CREW TASKS
FIELD OF VIEW <1°
MODES
COMMANDS

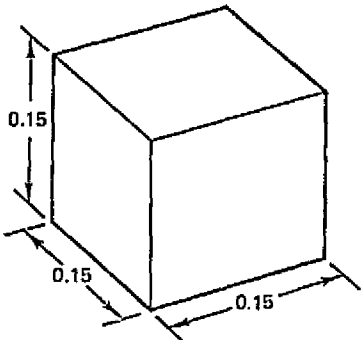
WIRING SCHEMATIC

- OPERATING SEQUENCE DESCRIPTION
- SPECIAL SUPPORT REQUIREMENTS
- CALIBRATION REQUIREMENTS:
 - PRE-LAUNCH
 - FLIGHT
 - POST-FLIGHT

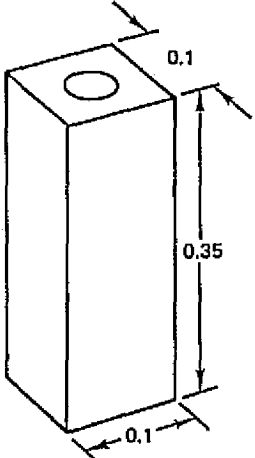
- 3.3.3 ESP electric and magnetic receivers. These receivers are designed to measure the intensity and frequency of electrostatic, electromagnetic, and magnetic waves propagating in the ionospheric plasma. They will cover the frequency range from 30 Hz to 20 MHz, and consist of a three-axis dipole antenna and a three axis search coil. These antennas are mounted on the ESP in order to remove them from the high background radiation produced by the Shuttle.

INSTRUMENT PERSPECTIVE	MASS PROPERTIES
	LAUNCH WT. = <u>21</u> KG LANDING WT. = <u>21</u> KG $I_x = \underline{\text{TBD}}$ KG-M² $I_y = \underline{\text{TBD}}$ KG-M² $I_z = \underline{\text{TBD}}$ KG-M²
	ELECTRICAL POWER
	TYPE <u>28 VDC</u> STANDBY _____ WATTS OPERATING <u>20</u> WATTS TOTAL ENERGY _____ KWH
	THERMAL CHARACTERISTICS
	MAX. EXT. TEMP. _____ °K POWER DISSIPATION CONDUCTED _____ WATTS RADIATED _____ WATTS TOTAL _____ WATTS
EQUIPMENT HAZARDS	OPERATING CHARACTERISTICS
	CONTROL <u>(MANUAL OR AUTOMATIC)</u> DUTY CYCLE _____ DATA RATE <u>5.9</u> KBPS OPERATING TIME _____ TOTAL CREW TASKS _____ FIELD OF VIEW <u>4π Steradians</u> MODES _____ COMMANDS _____
WIRING SCHEMATIC	• OPERATING SEQUENCE DESCRIPTION • SPECIAL SUPPORT REQUIREMENTS • CALIBRATION REQUIREMENTS: • PRE-LAUNCH • FLIGHT • POST-FLIGHT

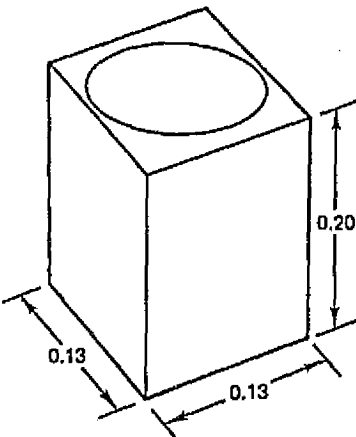
- 3.3.4 ESP DC electric field meter. The DC electric field meter will be used to measure the presence of steady state electric fields in the ionosphere. This instrument uses the electric field antennas of the electric field receiver as its sensor unit and consists only of an electronics box.

INSTRUMENT PERSPECTIVE 	MASS PROPERTIES LAUNCH WT. = <u>5</u> KG LANDING WT. = <u>5</u> KG I_x = <u>TBD</u> $\text{KG}\cdot\text{M}^2$ I_y = <u>TBD</u> $\text{KG}\cdot\text{M}^2$ I_z = <u>TBD</u> $\text{KG}\cdot\text{M}^2$
EQUIPMENT HAZARDS	ELECTRICAL POWER TYPE <u>28 VDC</u> STANDBY _____ WATTS OPERATING <u>5</u> WATTS TOTAL ENERGY _____ KWH
WIRING SCHEMATIC	THERMAL CHARACTERISTICS MAX. EXT. TEMP. _____ °K POWER DISSIPATION CONDUCTED _____ WATTS RADIATED _____ WATTS TOTAL _____ WATTS
	OPERATING CHARACTERISTICS CONTROL <u>(MANUAL OR AUTOMATIC)</u> DUTY CYCLE _____ DATA RATE _____ KBPS OPERATING TIME _____ TOTAL CREW TASKS _____ FIELD OF VIEW _____ MODES _____ COMMANDS _____ • OPERATING SEQUENCE DESCRIPTION • SPECIAL SUPPORT REQUIREMENTS • CALIBRATION REQUIREMENTS: • PRE-LAUNCH • FLIGHT • POST-FLIGHT

- 3.3.5 ESP medium energy electron detector. The medium energy detector is an electrostatic energy analyzer for electrons in the energy range from 100 to 40,000 electron volts. It has an energy resolution of about 15 percent and a dynamic range of 10^8 .

INSTRUMENT PERSPECTIVE		MASS PROPERTIES	
		LAUNCH WT. = 5 KG	
		LANDING WT. = 5 KG	
		$I_x = \text{TBD} \text{ KG-M}^2$	
		$I_y = \text{TBD} \text{ KG-M}^2$	
		$I_z = \text{TBD} \text{ KG-M}^2$	
EQUIPMENT HAZARDS		ELECTRICAL POWER	
		TYPE _____	
		STANDBY _____ WATTS	
		OPERATING 8 WATTS	
		TOTAL ENERGY _____ KWH	
WIRING SCHEMATIC		THERMAL CHARACTERISTICS	
		MAX. EXT. TEMP. _____ °K	
		POWER DISSIPATION	
		CONDUCTED _____ WATTS RADIATED _____ WATTS TOTAL _____ WATTS	
		OPERATING CHARACTERISTICS	
		CONTROL (MANUAL OR AUTOMATIC) _____	
		DUTY CYCLE _____	
		DATA RATE 5.3 KBPS	
		OPERATING TIME _____ TOTAL	
		CREW TASKS _____	
		FIELD OF VIEW 5° Half Cone	
		MODES _____	
		COMMANDS _____	
		• OPERATING SEQUENCE DESCRIPTION • SPECIAL SUPPORT REQUIREMENTS • CALIBRATION REQUIREMENTS: • PRE-LAUNCH • FLIGHT • POST-FLIGHT	

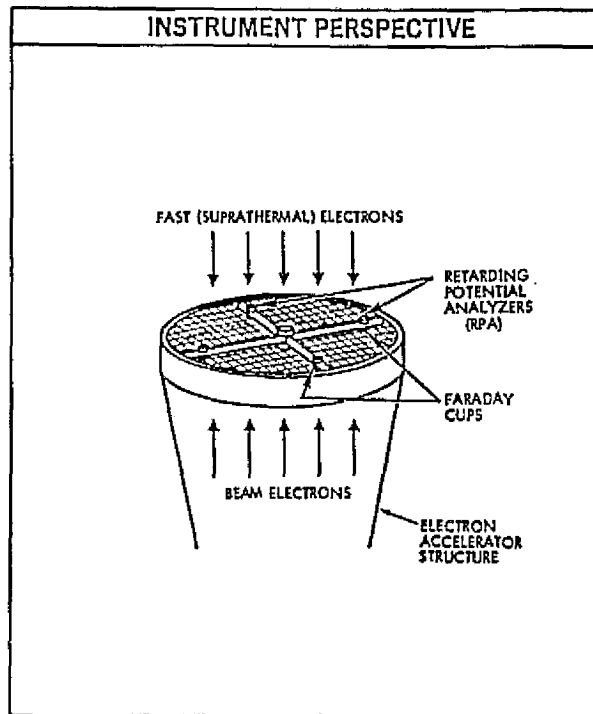
- 3.3.6 ESP ion mass and distribution analyzer. The ion mass and distribution analyzer measures the mass and energy distribution of thermal ionospheric ions. It uses electrostatic and magnetic deflections and will cover the range from 1 to 40 AMU. It uses the vehicle ram velocity to give the ions an equal velocity. It is placed on the ESP in order to avoid contamination near the Shuttle.

INSTRUMENT PERSPECTIVE		MASS PROPERTIES	
		LAUNCH WT. = <u>4</u> KG	
		LANDING WT. = <u>4</u> KG	
		$I_x = \text{TBD} \text{ KG-M}^2$	
		$I_y = \text{TBD} \text{ KG-M}^2$	
		$I_z = \text{TBD} \text{ KG-M}^2$	
EQUIPMENT HAZARDS		ELECTRICAL POWER	
		TYPE _____	
		STANDBY _____ WATTS	
		OPERATING <u>10</u> WATTS	
		TOTAL ENERGY _____ KWH	
WIRING SCHEMATIC		THERMAL CHARACTERISTICS	
		MAX. EXT. TEMP. _____ °K	
		POWER DISSIPATION	
		CONDUCTED _____ WATTS	
		RADIATED _____ WATTS	
		TOTAL _____ WATTS	
		OPERATING CHARACTERISTICS	
		CONTROL <u>(MANUAL OR AUTOMATIC)</u>	
		DUTY CYCLE _____	
		DATA RATE <u>5.7</u> KBPS	
		OPERATING TIME _____ TOTAL	
		CREW TASKS _____	
		FIELD OF VIEW <u>45° Half Cone</u>	
		MODES _____	
		COMMANDS _____	
		• OPERATING SEQUENCE DESCRIPTION • SPECIAL SUPPORT REQUIREMENTS • CALIBRATION REQUIREMENTS: • PRE-LAUNCH • FLIGHT • POST-FLIGHT	

- 3.3.7 Level 1 diagnostics. The Level 1 diagnostics consist of a set of gas jets arranged around the exit aperture of the electron accelerator, a set of valves, a gas storage chamber. For proper use of this diagnostic and the OBIPS is also required.

INSTRUMENT PERSPECTIVE		MASS PROPERTIES	
		LAUNCH WT. = <u>TBD</u> KG LANDING WT. = <u>TBD</u> KG $I_x = \underline{\hspace{1cm}} \text{ KG-M}^2$ $I_y = \underline{\hspace{1cm}} \text{ KG-M}^2$ $I_z = \underline{\hspace{1cm}} \text{ KG-M}^2$	
		ELECTRICAL POWER TYPE <u> </u> STANDBY <u> </u> WATTS OPERATING <u> </u> WATTS TOTAL ENERGY <u> </u> KWH	
		THERMAL CHARACTERISTICS MAX. EXT. TEMP. <u> </u> °K POWER DISSIPATION CONDUCTED <u> </u> WATTS RADIATED <u> </u> WATTS TOTAL <u> </u> WATTS	
		EQUIPMENT HAZARDS 	
		OPERATING CHARACTERISTICS CONTROL <u>(MANUAL OR AUTOMATIC)</u> DUTY CYCLE <u> </u> DATA RATE <u> </u> KBPS OPERATING TIME <u> </u> TOTAL CREW TASKS <u> </u> FIELD OF VIEW <u> </u> MODES <u> </u> COMMANDS <u> </u>	
WIRING SCHEMATIC 		• OPERATING SEQUENCE DESCRIPTION • SPECIAL SUPPORT REQUIREMENTS • CALIBRATION REQUIREMENTS: • PRE-LAUNCH • FLIGHT • POST-FLIGHT	

- 3.3.8 Level 2 diagnostics. The Level 2 diagnostics consist of a Langmuir probe, a set of Faraday cups and retarding potential analyzers and an electrostatic analyzer all mounted so that they can monitor the performance of the electron accelerator. The design details are TBD.



MASS PROPERTIES		
LAUNCH WT. =	TBD	KG
LANDING WT. =	TBD	KG
$I_x =$	TBD	KG-M ²
$I_y =$	TBD	KG-M ²
$I_z =$	TBD	KG-M ²

ELECTRICAL POWER		
TYPE		
STANDBY		WATTS
OPERATING		WATTS
TOTAL ENERGY		KWH

THERMAL CHARACTERISTICS		
MAX. EXT. TEMP.		°K
POWER DISSIPATION		
CONDUCTED		WATTS
RADIATED		WATTS
TOTAL		WATTS

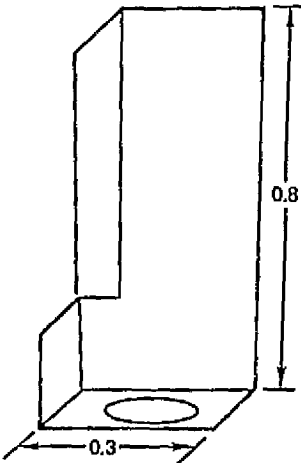
EQUIPMENT HAZARDS

OPERATING CHARACTERISTICS	
CONTROL	(MANUAL OR AUTOMATIC)
DUTY CYCLE	
DATA RATE	KBPS
OPERATING TIME	TOTAL
CREW TASKS	
FIELD OF VIEW	
MODES	
COMMANDS	

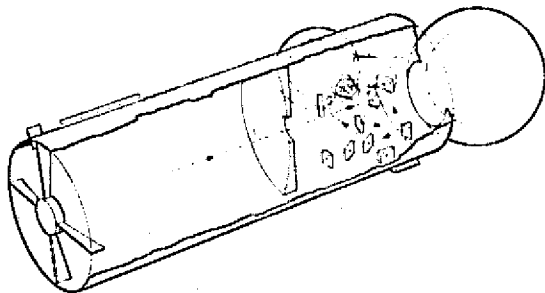
WIRING SCHEMATIC

- OPERATING SEQUENCE DESCRIPTION
- SPECIAL SUPPORT REQUIREMENTS
- CALIBRATION REQUIREMENTS:
 - PRE-LAUNCH
 - FLIGHT
 - POST-FLIGHT

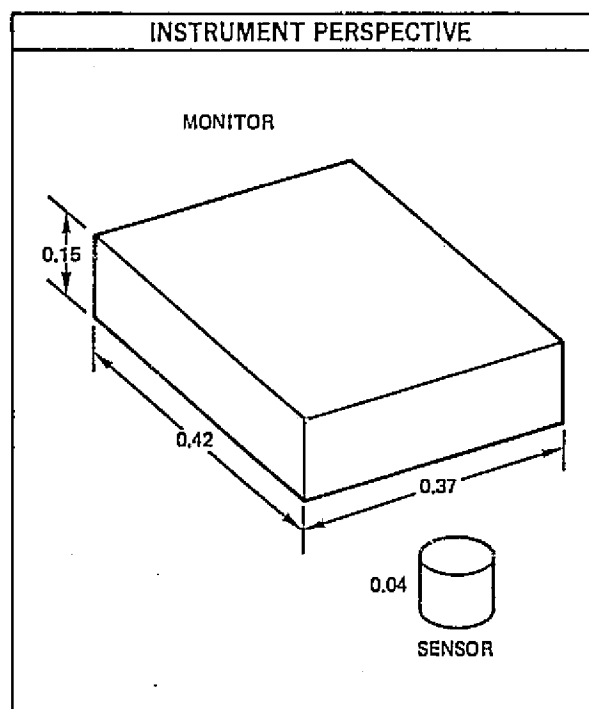
- 3.3.9 Optical band imaging system (OBIPS). The optical band imager consists of an image intensified vidicon tube which will be able to give a full video picture every 1/60th second.

INSTRUMENT PERSPECTIVE		MASS PROPERTIES	
		LAUNCH WT. = 93 KG	
		LANDING WT. = 93 KG	
		$I_x = \text{TBD} \text{ KG-M}^2$	
		$I_y = \text{TBD} \text{ KG-M}^2$	
		$I_z = \text{TBD} \text{ KG-M}^2$	
EQUIPMENT HAZARDS		ELECTRICAL POWER	
		TYPE _____	
		STANDBY _____ WATTS	
		OPERATING 27 WATTS	
		TOTAL ENERGY _____ KWH	
WIRING SCHEMATIC		THERMAL CHARACTERISTICS	
		MAX. EXT. TEMP. _____ °K	
		POWER DISSIPATION	
		CONDUCTED _____ WATTS RADIATED _____ WATTS TOTAL _____ WATTS	
		OPERATING CHARACTERISTICS	
		CONTROL (MANUAL OR AUTOMATIC) _____	
		DUTY CYCLE _____	
		DATA RATE 10 KBPS	
		OPERATING TIME _____ TOTAL	
		CREW TASKS _____	
		FIELD OF VIEW 16° Half Cone	
		MODES _____	
		COMMANDS _____	
		• OPERATING SEQUENCE DESCRIPTION • SPECIAL SUPPORT REQUIREMENTS • CALIBRATION REQUIREMENTS: • PRE-LAUNCH • FLIGHT • POST-FLIGHT	

- 3.3.10 Infrared interferometer cryogenic limb scanner. This instrument consists of a collecting optics telescope cooled to liquid nitrogen temperatures and a set of detectors cooled as low as 10°K which are intended to cover the range from 1 to 40 microns of atmospheric emissions. The whole assembly will be scanned across the earth's limb and will have a height resolution of 1 kilometer. Spectral resolution will be determined by the interferometer mirror speed, data reduction rates and the length of the mirror throw.

INSTRUMENT PERSPECTIVE		MASS PROPERTIES	
	LAUNCH WT. = 20 KG	LANDING WT. = 20 KG	
	$I_x = \text{TBD}$ KG-M ²	$I_y = \text{TBD}$ KG-M ²	
	$I_z = \text{TBD}$ KG-M ²		
		ELECTRICAL POWER	
		TYPE _____	
		STANDBY _____ WATTS	
		OPERATING 156 WATTS	
		TOTAL ENERGY _____ KWH	
		THERMAL CHARACTERISTICS	
		MAX. EXT. TEMP. _____ °K	
		POWER DISSIPATION	
		CONDUCTED _____ WATTS	
		RADIATED _____ WATTS	
		TOTAL _____ WATTS	
EQUIPMENT HAZARDS		OPERATING CHARACTERISTICS	
		CONTROL (MANUAL OR AUTOMATIC) _____	
		DUTY CYCLE _____	
		DATA RATE 2500 KBPS	
		OPERATING TIME _____ TOTAL	
		CREW TASKS _____	
		FIELD OF VIEW <1°	
		MODES _____	
		COMMANDS _____	
WIRING SCHEMATIC		• OPERATING SEQUENCE DESCRIPTION • SPECIAL SUPPORT REQUIREMENTS • CALIBRATION REQUIREMENTS: • PRE-LAUNCH • FLIGHT • POST-FLIGHT	

- 3.3.11 Quartz crystal microbalance. This microbalance measures the weight of material that is deposited on it during the flight of the Shuttle by measuring the change in oscillation frequency of a quartz crystal. Sensing units will be placed at various points on the payload in order to map out the surface contamination loads during the flight. The unit consists of a sensor on the payload and a monitor in the module.



MASS PROPERTIES		
LAUNCH WT. =	7	KG
LANDING WT. =	7	KG
$I_x =$	TBD	KG-M ²
$I_y =$	TBD	KG-M ²
$I_z =$	TBD	KG-M ²

ELECTRICAL POWER		
TYPE		
STANDBY		WATTS
OPERATING	20	WATTS
TOTAL ENERGY		KWH

THERMAL CHARACTERISTICS		
MAX. EXT. TEMP.		°K
POWER DISSIPATION		
CONDUCTED		WATTS
RADIATED		WATTS
TOTAL		WATTS

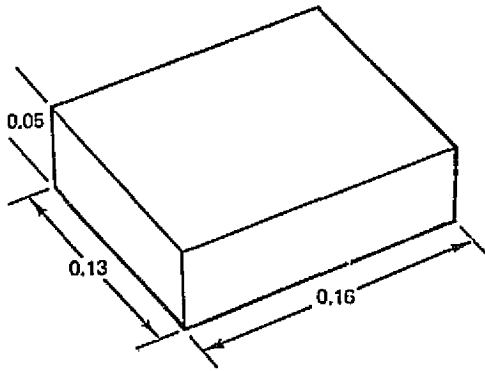
EQUIPMENT HAZARDS

OPERATING CHARACTERISTICS
CONTROL (MANUAL OR AUTOMATIC)
DUTY CYCLE
DATA RATE 0.64 KBPS
OPERATING TIME TOTAL
CREW TASKS
FIELD OF VIEW 70° Half Cone
MODES
COMMANDS

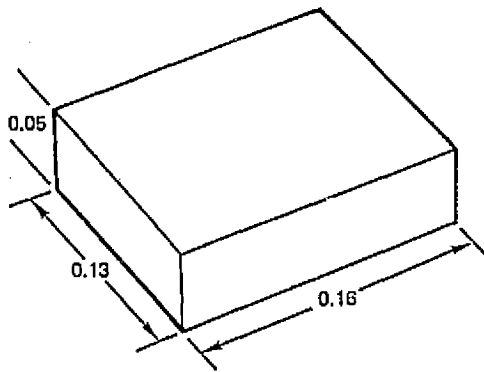
WIRING SCHEMATIC

- OPERATING SEQUENCE DESCRIPTION
- SPECIAL SUPPORT REQUIREMENTS
- CALIBRATION REQUIREMENTS:
 - PRE-LAUNCH
 - FLIGHT
 - POST-FLIGHT

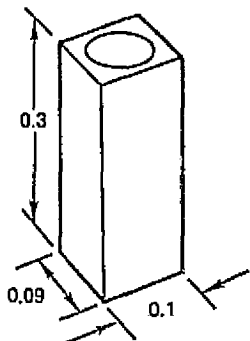
- 3.3.12 Vector magnetometer. This magnetometer is to be used to determine the magnetic orientation of the Orbiter. It will be a simple three-axis fluxgate magnetometer with a 5 Hz bandwidth from DC. It will be necessary to mount the magnetometer on a short mast to reduce the Shuttle background magnetic fields.

INSTRUMENT PERSPECTIVE		MASS PROPERTIES	
		LAUNCH WT. = <u>2</u> KG	
		LANDING WT. = <u>2</u> KG	
		$I_x = \text{TBD} \text{ KG-M}^2$	
		$I_y = \text{TBD} \text{ KG-M}^2$	
		$I_z = \text{TBD} \text{ KG-M}^2$	
EQUIPMENT HAZARDS		ELECTRICAL POWER	
		TYPE _____	
		STANDBY _____ WATTS	
		OPERATING <u>2</u> WATTS	
		TOTAL ENERGY _____ KWH	
WIRING SCHEMATIC		THERMAL CHARACTERISTICS	
		MAX. EXT. TEMP. _____ °K	
		POWER DISSIPATION	
		CONDUCTED _____ WATTS	
		RADIATED _____ WATTS	
		TOTAL _____ WATTS	
		OPERATING CHARACTERISTICS	
		CONTROL (MANUAL OR AUTOMATIC)	
		DUTY CYCLE _____	
		DATA RATE <u>0.005</u> KBPS	
		OPERATING TIME _____ TOTAL	
		CREW TASKS _____	
		FIELD OF VIEW <u>N/A</u>	
		MODES _____	
		COMMANDS _____	
		• OPERATING SEQUENCE DESCRIPTION • SPECIAL SUPPORT REQUIREMENTS • CALIBRATION REQUIREMENTS: • PRE-LAUNCH • FLIGHT • POST-FLIGHT	

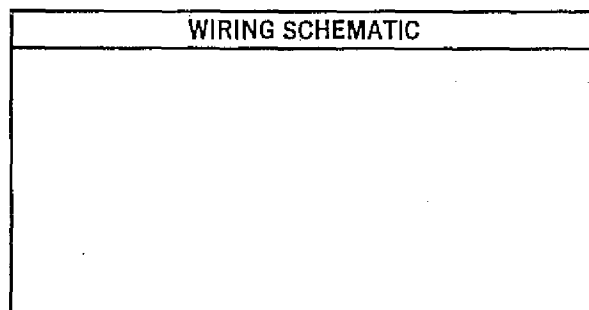
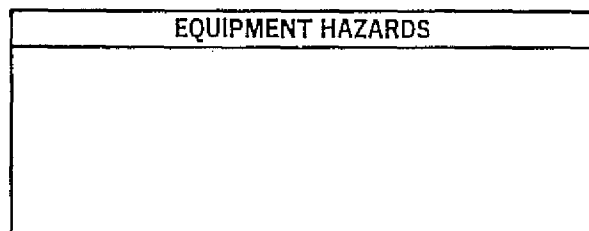
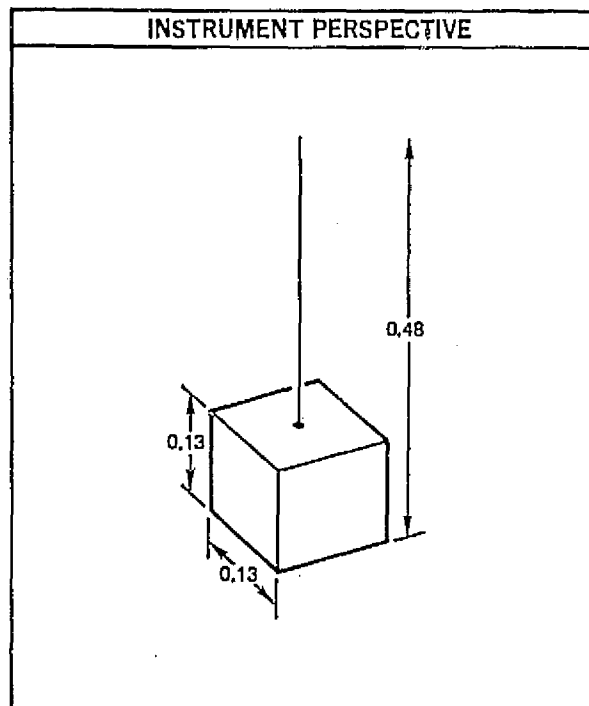
3.3.13 ESP magnetometer. Will be used to determine the magnetic orientation of the ESP packages. It will be identical to the vector magnetometer described in 3.3.13.

INSTRUMENT PERSPECTIVE	MASS PROPERTIES
	LAUNCH WT. = <u>2</u> KG LANDING WT. = <u>2</u> KG $I_x = \text{TBD} \text{ KG-M}^2$ $I_y = \text{TBD} \text{ KG-M}^2$ $I_z = \text{TBD} \text{ KG-M}^2$
	ELECTRICAL POWER
	TYPE _____ STANDBY _____ WATTS OPERATING <u>2</u> WATTS TOTAL ENERGY _____ KWH
	THERMAL CHARACTERISTICS
	MAX. EXT. TEMP. _____ °K POWER DISSIPATION CONDUCTED _____ WATTS RADIATED _____ WATTS TOTAL _____ WATTS
EQUIPMENT HAZARDS	OPERATING CHARACTERISTICS
	CONTROL (MANUAL OR AUTOMATIC) _____ DUTY CYCLE _____ DATA RATE <u>0.005</u> KBPS OPERATING TIME _____ TOTAL CREW TASKS _____ FIELD OF VIEW <u>N/A</u> MODES _____ COMMANDS _____
WIRING SCHEMATIC	• OPERATING SEQUENCE DESCRIPTION • SPECIAL SUPPORT REQUIREMENTS • CALIBRATION REQUIREMENTS: • PRE-LAUNCH • FLIGHT • POST-FLIGHT

- 3.3.14 Solar flux monitor. The solar flux monitor is used to determine the absolute emission intensity of the sun as a function of wavelength in the range from 30 to 350 nanometers. It is a scanning spectrometer with a calibrated detector.

INSTRUMENT PERSPECTIVE		MASS PROPERTIES	
		LAUNCH WT. = 50 KG	
		LANDING WT. = 50 KG	
		$I_x = \text{TBD} \text{ KG-M}^2$	
		$I_y = \text{TBD} \text{ KG-M}^2$	
		$I_z = \text{TBD} \text{ KG-M}^2$	
EQUIPMENT HAZARDS		ELECTRICAL POWER	
		TYPE _____	
		STANDBY _____ WATTS	
		OPERATING 6 WATTS	
		TOTAL ENERGY _____ KWH	
WIRING SCHEMATIC		THERMAL CHARACTERISTICS	
		MAX. EXT. TEMP. _____ °K	
		POWER DISSIPATION	
		CONDUCTED _____ WATTS	
		RADIATED _____ WATTS	
		TOTAL _____ WATTS	
		OPERATING CHARACTERISTICS	
		CONTROL (MANUAL OR AUTOMATIC)	
		DUTY CYCLE _____	
		DATA RATE 3.2 KBPS	
		OPERATING TIME _____ TOTAL	
		CREW TASKS _____	
		FIELD OF VIEW ≈ 1°	
		MODES _____	
		COMMANDS _____	
		• OPERATING SEQUENCE DESCRIPTION • SPECIAL SUPPORT REQUIREMENTS • CALIBRATION REQUIREMENTS: • PRE-LAUNCH • FLIGHT • POST-FLIGHT	

- 3.3.15 ESP Langmuir probe. Langmuir probe is a cylinder and is used to determine the ambient ionospheric electron density and temperature. It is mounted on the ESP so that the electron characteristics can be measured in regions that are not perturbed by the Shuttle.



MASS PROPERTIES	
LAUNCH WT. =	3.2 KG
LANDING WT. =	3.2 KG
I_x =	TBD KG-M ²
I_y =	TBD KG-M ²
I_z =	TBD KG-M ²

ELECTRICAL POWER	
TYPE	_____
STANDBY	_____ WATTS
OPERATING	5 WATTS
TOTAL ENERGY	_____ KWH

THERMAL CHARACTERISTICS	
MAX. EXT. TEMP.	_____ °K
POWER DISSIPATION	
CONDUCTED	_____ WATTS
RADIATED	_____ WATTS
TOTAL	_____ WATTS

OPERATING CHARACTERISTICS	
CONTROL	(MANUAL OR AUTOMATIC)
DUTY CYCLE	_____
DATA RATE	2.7 KBPS
OPERATING TIME	_____ TOTAL
CREW TASKS	_____
FIELD OF VIEW	4 π Steradians
MODES	_____
COMMANDS	_____

- OPERATING SEQUENCE DESCRIPTION
- SPECIAL SUPPORT REQUIREMENTS
- CALIBRATION REQUIREMENTS:
 - PRE-LAUNCH
 - FLIGHT
 - POST-FLIGHT

- 3.3.16 ESP neutral mass spectrometer. The neutral mass spectrometer covers the mass range from 1 to 64 AMU with a sensitivity on the order of 100 particles per cubic centimeter. It operates by looking into the vehicle ram direction and energy analyzing the particles.

INSTRUMENT PERSPECTIVE		MASS PROPERTIES	
		LAUNCH WT. = <u>5</u> KG	
		LANDING WT. = <u>5</u> KG	
		$I_x = \underline{\text{TBD}}$ KG-M ²	
		$I_y = \underline{\text{TBD}}$ KG-M ²	
		$I_z = \underline{\text{TBD}}$ KG-M ²	
		ELECTRICAL POWER	
		TYPE _____	
		STANDBY _____ WATTS	
		OPERATING <u>40</u> WATTS	
		TOTAL ENERGY _____ KWH	
		THERMAL CHARACTERISTICS	
		MAX. EXT. TEMP. _____ °K	
		POWER DISSIPATION	
		CONDUCTED _____ WATTS	
		RADIATED _____ WATTS	
		TOTAL _____ WATTS	
EQUIPMENT HAZARDS		OPERATING CHARACTERISTICS	
		CONTROL <u>(MANUAL OR AUTOMATIC)</u>	
		DUTY CYCLE _____	
		DATA RATE <u>5.7</u> KBPS	
		OPERATING TIME _____ TOTAL	
		CREW TASKS _____	
		FIELD OF VIEW <u>30° Half Cone</u>	
		MODES _____	
		COMMANDS _____	
WIRING SCHEMATIC		• OPERATING SEQUENCE DESCRIPTION • SPECIAL SUPPORT REQUIREMENTS • CALIBRATION REQUIREMENTS: • PRE-LAUNCH • FLIGHT • POST-FLIGHT	

3.4 LABCRAFT SUPPORT EQUIPMENT. This section describes the inventory of Labcraft support equipment required to support the Flight 1 mission. It includes the following items:

- Environmental sensor package (ESP)
- SIPS Internal support structure
- Cryogenic canister
- Gas release
- Controls and displays
- Common energy storage system
- Magnetometer mast

3.4.1 Environmental sensor package (ESP). The principle function of the ESP to be used on Flight 1 is to position a set of passive instruments remote from the Orbiter (TBD to TBD km) to measure the space environment. The ESP will be deployed from the Orbiter via the remote manipulator system (RMS). It will operate attached to the Orbiter and will provide necessary support functions (i.e., power, communication, data processing) to the instrument payload. Communications will be established with the Orbiter via the payload interrogator link. The ESP will be retracted by the Orbiter RMS and will be returned to the ground for reuse. The EPS must be mounted on a pallet so as to allow free access for the RMS to permit safe deployment and retrieval. Other features of the ESP are shown in Figure 3.4.1-1. The ESP will carry the following complement of instruments:

- Electric and magnetic receivers
- DC electric field meter
- Medium energy electron detector
- Ion mass and distribution analyzer
- Vector magnetometer
- Langmuir probe
- Neutral mass spectrometer

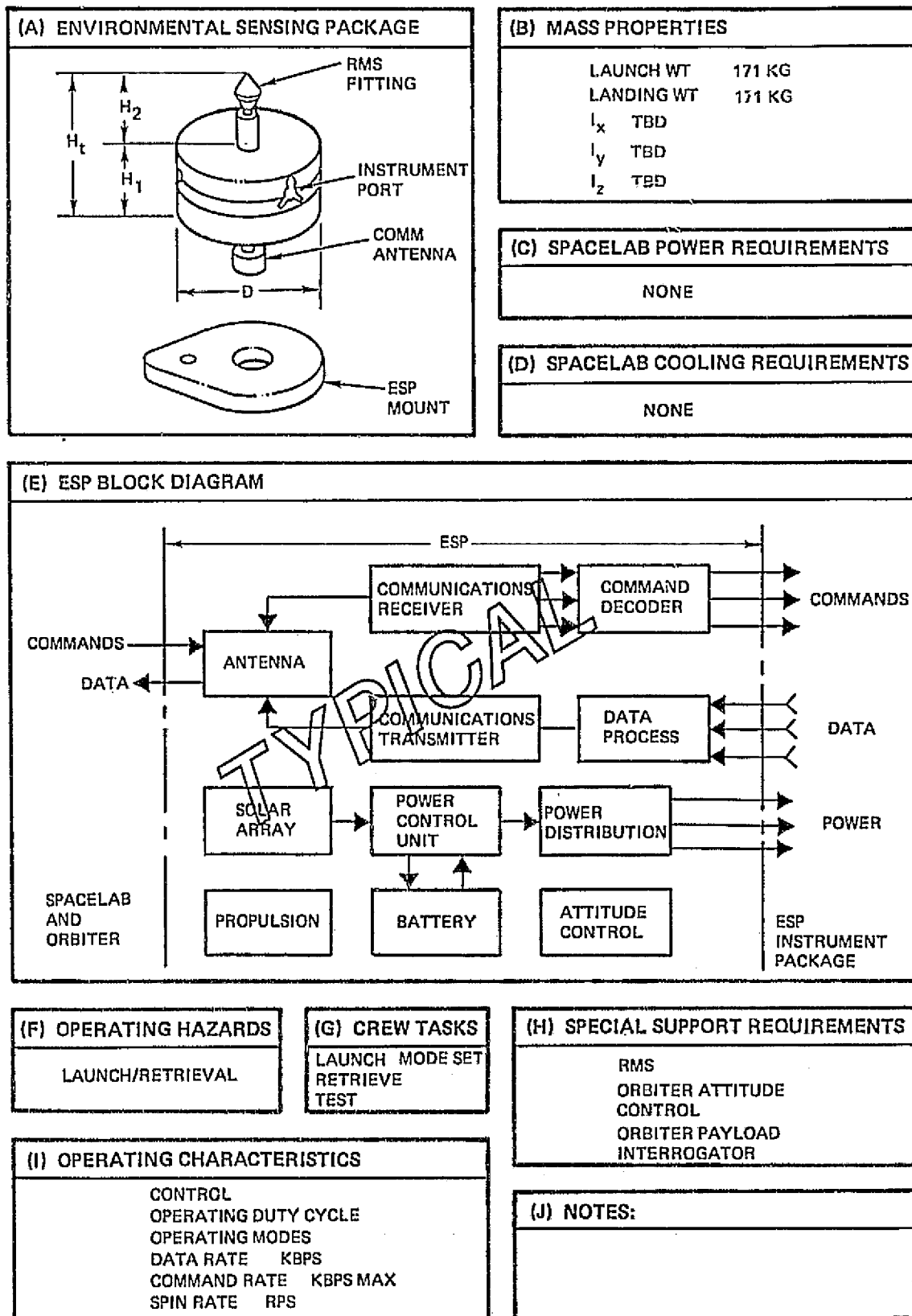


Figure 3.4.1-1. Environmental Sensor Package

3.4.2 SIPS Internal Support Structure. The basic function of the SIPS internal support structure is to provide a satisfactory method for mounting instruments inside the SIPS canister housings. Details of the structure designs for Flight 1 are shown in Figure 3.4.2-1.

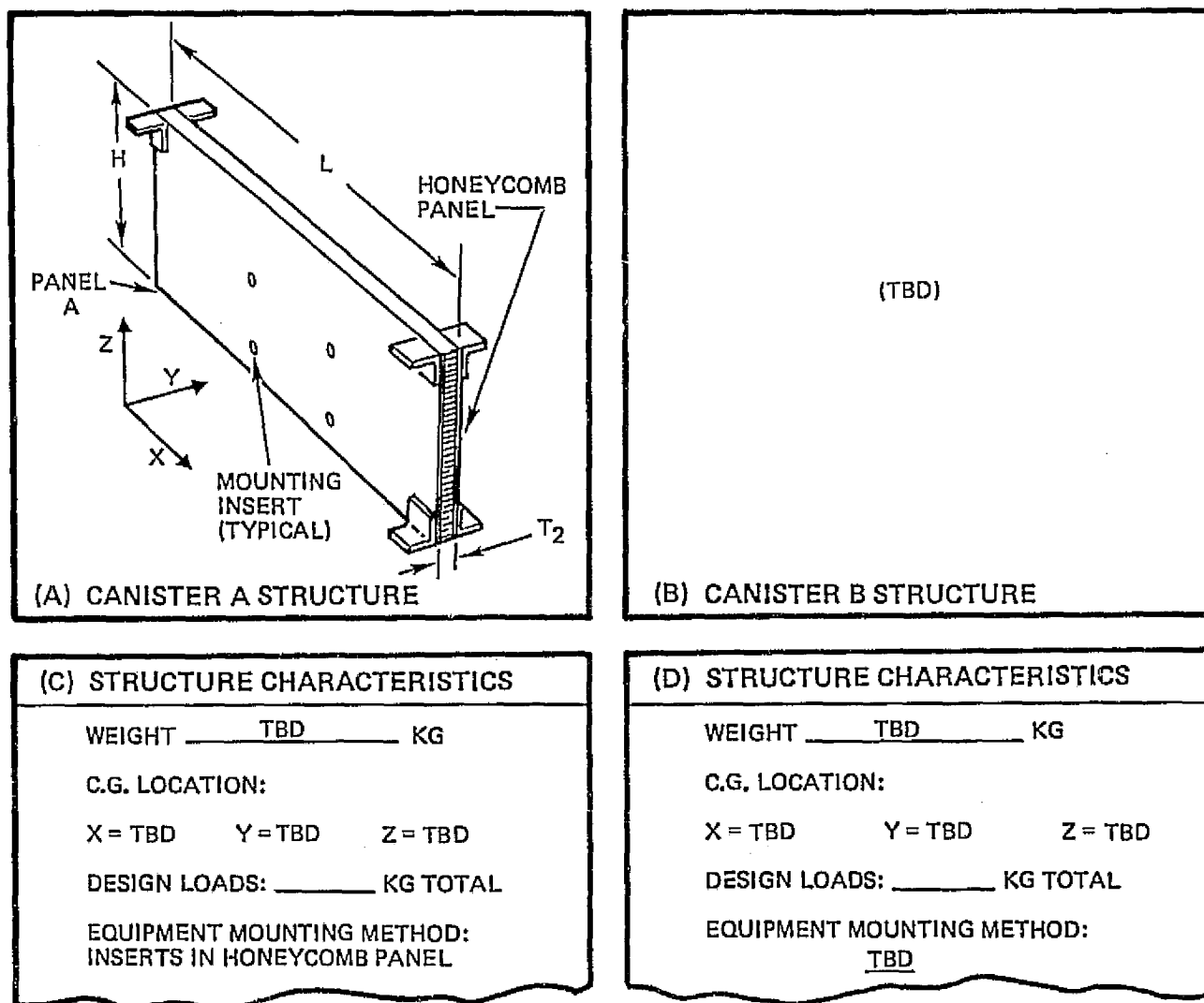


Figure 3.4.2-1. SIPS Internal Support Structure

- 3.4.3 Cryogenic Canister. The purpose of the cryogenic canister is to establish the desired operating temperature for selected instrument detectors. As used on Flight 1, the instruments are located on the SIPS and are connected to the canister prior to SIPS deployment (see Figure 3.4.3-1. When the SIPS is deployed, the lines between the canister and the instrument detectors are severed and simultaneously sealed. The instrument will then operate for some (limited) time period before the detector temperature rises to an unacceptably high value.

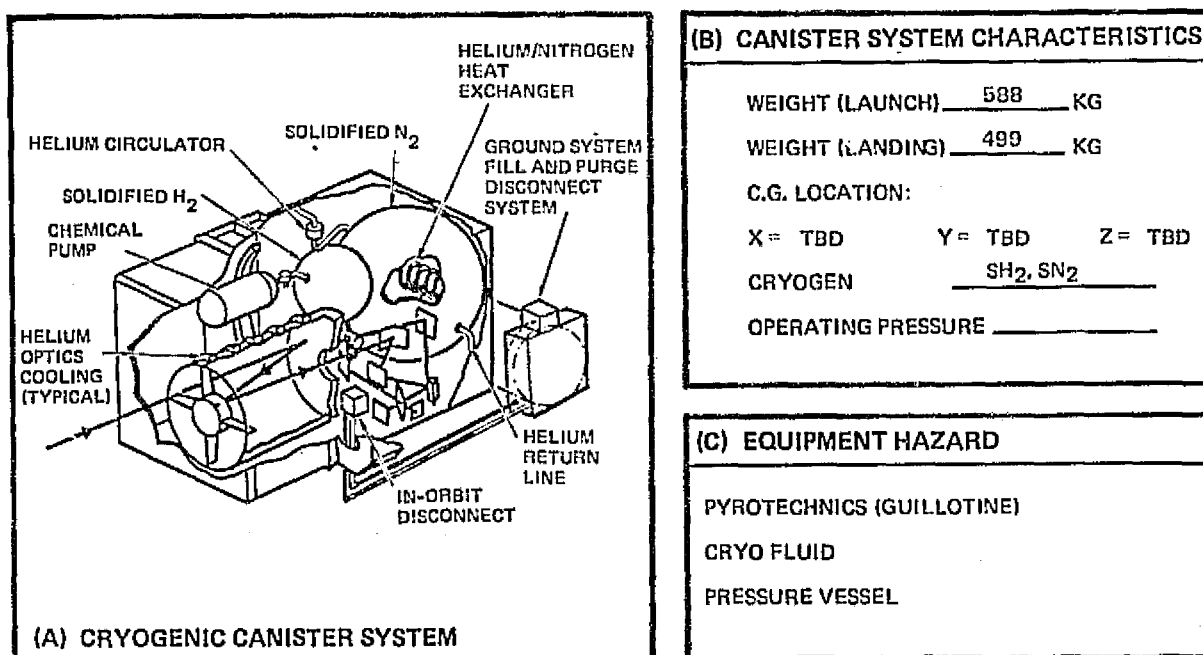


Figure 3.4.3-1. Cryogenic Canister

- 3.4.4 Gas Release. The gas release system is designed to launch gas containers into orbits which are nominally identical with the Shuttle Orbiter. Variations in the final orbit of the gas containers may be achieved by varying the Orbiter position (launch direction) or the separation velocity or both. Additional information on the system for Flight 1 is presented in Figure 3.4.4-1.

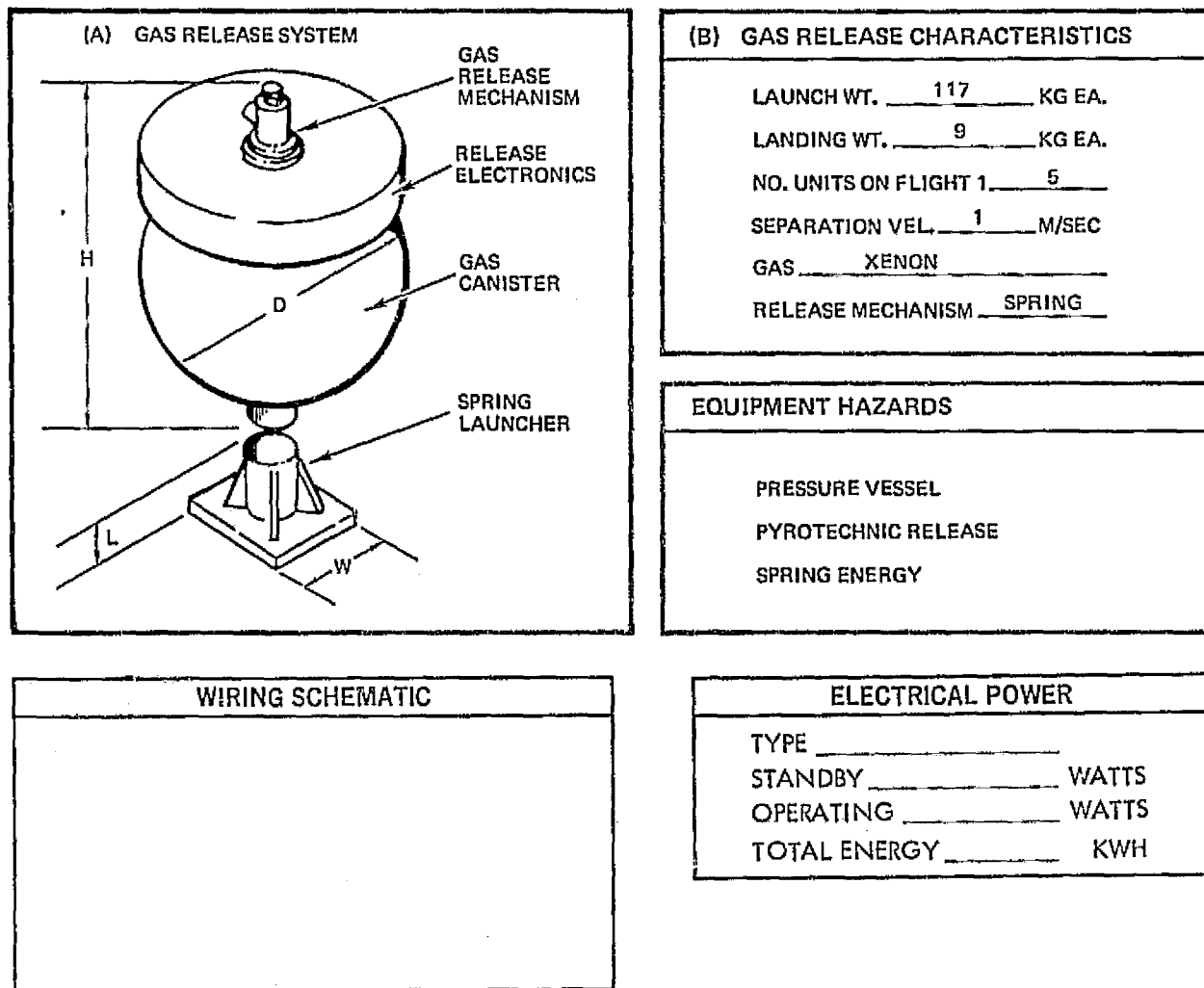


Figure 3.4.4-1. Gas Release

3.4.5 Controls and displays (C&D). The Labcraft C&D equipment is designed to augment the Spacelab capabilities. Specifically, it serves the following functions:

- (a) Satisfies the caution and warning requirements imposed by Spacelab on payloads
- (b) Provides safing and arming capability for payload equipment (e.g., gas releases)
- (c) Provides special control and data processing capabilities not available from the Spacelab CDMS
- (d) Includes special equipment (e.g., the analog tape recorder) not provided by Spacelab but necessary to support Labcraft payload operations.

Figure 3.4.5-1 summarizes the key features of the Labcraft - dedicated C&D equipment for Flight 1. See Figure 3.2-2 for layout of Flight 1 controls and displays.

UNIT DESCRIPTION	SIZE (M)			WEIGHT (KG)	AVERAGE POWER (WATTS)	C.G. LOCATION		
	X	Y	Z			X	Y	Z
NIM-CAMAC EQUIPMENT				80				
QCMB CONTROLLER				20				
LIDAR CONTROLLER				20				
OBIPS CONTROLLER				25				
SIPS CONTROLLER				30				
BULK DATA STORAGE DEVICE				22				

Figure 3.4.5-1. Flight 1 C&D Characteristics

- 3.4.6 Common energy storage system. Several Labcraft instruments (e.g., the LIDAR and the accelerator) require high energy electrical pulses for operation. The common energy storage system can provide high energy pulses at 500 volts maximum, with individual instruments providing additional high voltage processing. Further details on the common energy storage system are shown in Figure 3.4.6-1.

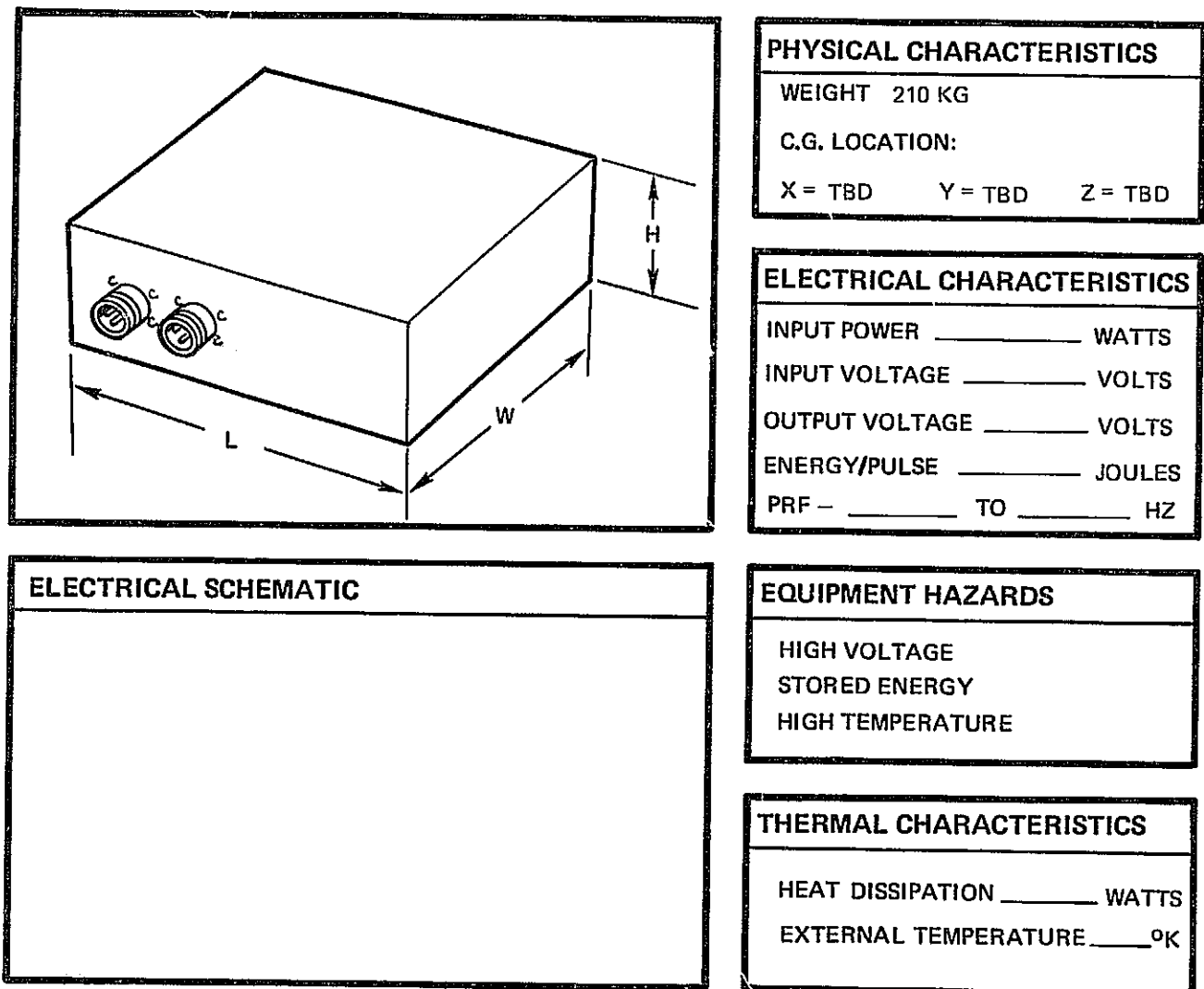


Figure 3.4.6-1. Common Energy Storage System

- 3.4.7 Magnetometer mast. The magnetometer mast is used to place a magnetometer outside the magnetic environment of the Orbiter. In operation, it will deploy, position, and point the magnetometers to the desired orientation in accordance with the preselected installation/alignment. The mast system will include a cable to provide power and signal wiring between Spacelab and the mast-mounted magnetometer. When the experiment work is completed, the mast will be retracted into the cargo bay and stowed for landing. Figure 3.4.7-1 shows the details of the magnetometer mast.

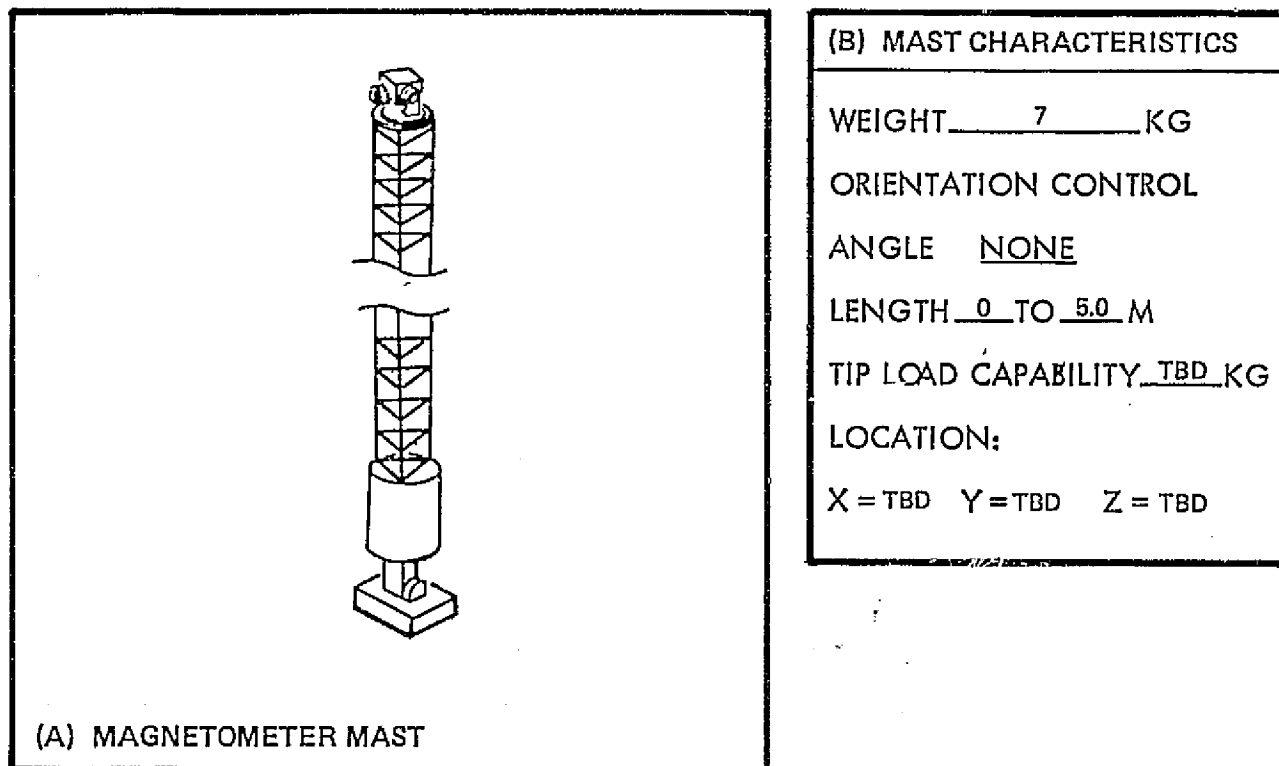


Figure 3.4.7-1. Magnetometer Mast

- 3.4.8 Cabling. The principal function of the support cabling is to connect elements of the Labcraft payload to the various Spacelab and Orbiter electrical services such as power, data processing, commands, communications, and caution and warning (C&W). Support cabling will also be required to interconnect segments of the payload such as support equipment to other support equipment or support equipment to instruments. Specific details of cabling requirements for Flight 1 are contained in Table III.IV.II-1.

Table III.IV.II-1. Flight 1 Cabling

Cable ID	Location	Cable Routing	No. Wires	Weight (kg)	Length (m)	C.G. Location		
						X	Y	Z
CM 1	Module	EPDB to ESP	TBD	TBD	TBD	TBD	TBD	TBD

3.5 COMMON PAYLOAD SUPPORT EQUIPMENT (CPSE). The following items of Spacelab CPSE have been identified as required to support Flight 1:

(none)

3.6 SPACELAB MISSION DEPENDENT EQUIPMENT (MDE). The Labcraft Flight 1 configuration includes certain Spacelab mission dependent equipment as noted in Table III.VI-1.

Table III.VI-1. Spacelab Mission Dependent Equipment

Equipment Description	Unit Weight (kg)	Quantity	Total Weight (kg)
Single Rack	36.1	2	72.2
Double Rack	57.3	2	114.6
Pallet Hardpoints	1		
Cold Plate	6.3	5	31.5
Cold Plate Standoff	0.9	30	27
Thermal Capacitor	12.5	0	0
Freon Line System	TBD	TBD	TBD
Pallet Thermal Cover	19.8	3	59.4
Experiment Switch Panel	3.7	1	3.7
Power Harness	50	1	50
Experiment Computer	30.4	1	30.4
Experiment I/O Unit	29.5	1	29.5
Experiment RAU	8.9	10	89
Keyboard	4.5	3	13.50
CRT Display	24.25	3	72.75
Hi Bit Rate Recorder	43	1	43
High Rate Multiplexer	11	1	11

3.7 MULTI-MISSION SUPPORT EQUIPMENT (MMSE). The Labcraft Flight 1 payload contains the following MMSE.

3.7.1 Small Instrument Pointing System (SIPS). The SIPS provides a highly accurate pointing platform for selected Labcraft instruments. It features dual equipment housing mounted on an azimuth-elevation type pedestal. Both equipment canisters are tied to the same azimuth bearing, but can be pointed independently in elevation. An optional roll bearing is also available with the SIPS and is used on Flight 1. The canisters include a self-contained thermal control system, and are designed to accommodate payload power and signal harnesses. The Flight 1 design includes a special cryogenic cooling system (see 3.4.3 above), Spacelab MDE as listed in Table III.VI-1, and an inventory of instruments per Table (TBD).

3.7.1.1 In operation, the SIPS will be retracted/stowed during the launch phase of Orbiter flight. When proper conditions for use are established, the Orbiter will be oriented and the SIPS deployed. A targeting routine (may be manual, pre-programmed, or closed loop) will be established and scientific data collected. When the experiments are completed, the SIPS is retracted and stowed for reentry.

3.7.1.2 Instruments generally will not interface directly with the SIPS canisters and consequently a mounting structure (see 3.4.2) must be provided. In addition, the SIPS will require certain items of Spacelab MDE (see 3.6) to be incorporated in the canisters to support the scientific instruments. Additional data on the SIPS is contained in Figure 3.7.1-1.

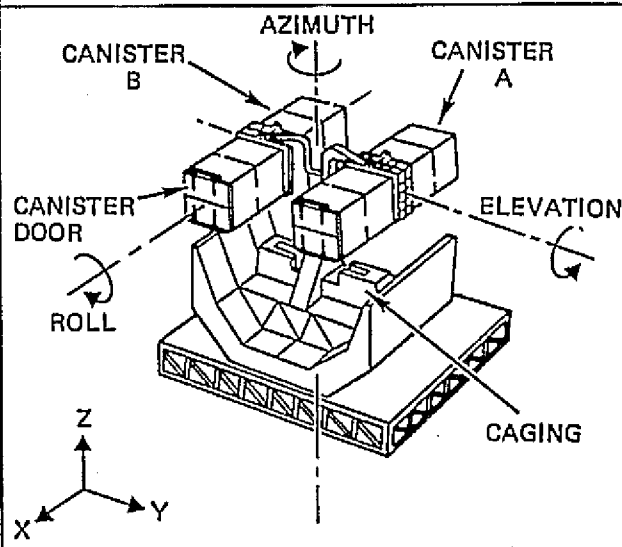
(A) SIPS 	(B) SIPS CHARACTERISTICS MASS <u>1406</u> KG AVERAGE POWER <u> </u> WATTS C.G. LOCATION: X = <u> </u> Y = <u> </u> Z = <u> </u> (C) PERFORMANCE POINTING <u>5.5</u> SEC STABILITY <u>1.4</u> SEC/SEC TEMP CONTROL <u> </u> °K SLEW RATES (DEG/SEC): AZ <u> </u> EL <u> </u> ROLL <u> </u> WEIGHT CAPABILITY <u> </u> KG
(D) EQUIPMENT HAZARDS	(E) OPERATING MODES
(F) SIPS BLOCK DIAGRAM TBD	

Figure 3.7.1-1. Small Instrument Pointing System

- 3.8 SOFTWARE CONFIGURATION. The following flight software packages that will be on the Certified flight tape, control number (TBD), are required to support this mission. These packages will be used in the CDMS experiment flight computer. All packages are written on the mass memory unit tape. The number of copies of each package written on the tape is (TBD). All permanently resident packages are loaded in the experiment computer at liftoff, as are the application packages supporting the first operations planned after the orbit phase has started. The following flight software packages are delivered by ESA and are required for Flight 1:

Experiment Computer Operating System	(Resident)
Checkout Language Interpreter	(Resident if space permits)
Keyboard Interpreter	(Resident if space permits)
Experiment CDMS Checkout and	(Non-resident)
Fault Isolation	
In-flight Monitor	(Resident)

The following are Labcraft flight software packages for Flight 1:

(a) Labcraft Coordination Package

Labcraft System Management	(Resident)
----------------------------	------------

(b) AMPS Instrument and Flight Support Equipment Management Packages

Chemical gas release	(Non-resident)
Electron accelerator control	
Vector magnetometer	
Level 1 diagnostics	
Level 2 diagnostics	
Cryo Infra-red limb scanner radiometer	
Cryo interferometer spectrometer	
Quartz crystal microbalance	
Lidar	
OBIPS	
Solar flux monitor	
SIPS control	
Mast control	
Electrostatic analyzer	
Medium energy electron detector	
DC electric field meter	
E and B receivers	
Langmuir probe	
ESP telemetry stream processor	(Non-resident)

(c) AMPS Experiment Management Packages

Each package may consist of several subpackages which can be independently called. However, it is expected that the solar radiation package will consist of a single package that will be called as a unit.

Vehicle neutralization
Accelerator beam characteristics
Beam - plasma interactions
Acoustic gravity wave
Gas jet expansion dynamics
Minor constituents
Ozone density
Environment measurements
Solar radiation monitor

(Non-resident)

(Non-resident)

(d) On-Board Test Packages

There will be one on-board test package for each instrument and flight support equipment carried for Labcraft that requires test prior to, during, or after experiment use. On-board test packages will be independently called for by the flight operator. They are all non-resident.

- 3.9 FLIGHT DATA FILE (FDF). The FDF required to support the AMPS is composed of the Spacelab flight dependent FDF and the unique AMPS FDF. The FDF requirement is shown in Table III.IX-1.

Table III.IX-1. AMPS Flight Data File

STS Flight Dependent	AMPS
Spacelab systems check lists (C/L)	Experiment C/L
Spacelab software C/L	Log books
Spacelab activation C/L	Payload schematics
Spacelab deactivation C/L	Payload malfunction procedures
Spacelab schematics	Payload flight plan
Spacelab malfunction procedures	Experiment reference data
Cue cards	Cue cards
Module subsystem operations	Experiment operations
Pallet subsystem operations	NIM/CAMAC operations
Deployment/retrieval C/L	Note books
	Scratch pads

- 3.10 MISCELLANEOUS EQUIPMENT. This section identifies any equipment, tool, or supporting data required by AMPS which is not included in one of the standard categories previously discussed. The miscellaneous equipment is (TBD).

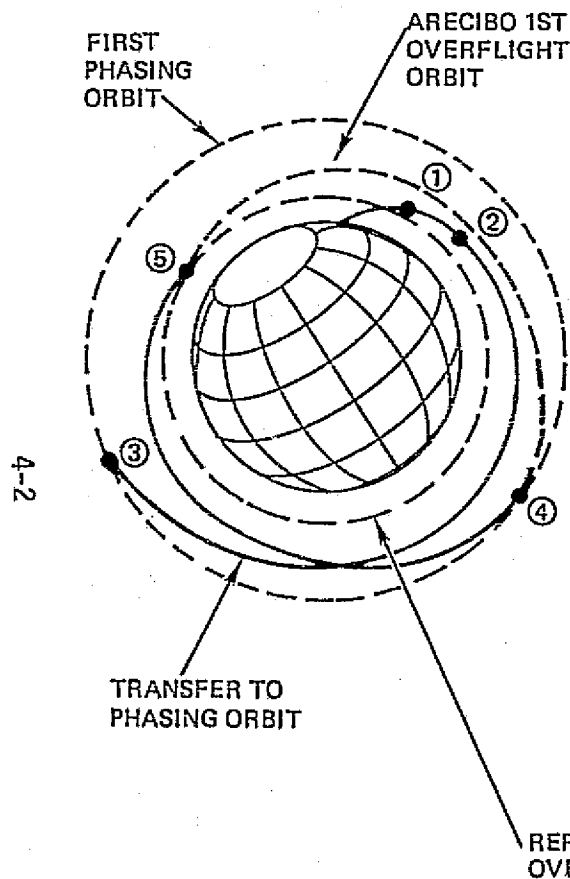
4. PAYLOAD FLIGHT REQUIREMENTS

4.1 FLIGHT PLAN.

4.1.1 Orbit Characteristics. The mission profile for Flight 1, illustrated in Figures 4.1.1-1 through 4.1.1-3, begins with a northeasterly launch from the Eastern Test Range into a 104 x 302 km orbit inclined 52.9 degrees. Six major OMS maneuvers are required during the mission to accomplish the orbit injection, transfer, and deboost. The first maneuver, $\Delta V = 70$ m/sec, is considered part of the Shuttle/Orbiter initial orbit injection sequence. The second maneuver, $\Delta V = 64$ m/sec occurs at first apogee raising perigee to the altitude of the initial phasing orbit. One-half revolution later, again at apogee, perigee is raised to 340 km with a $\Delta V = 6.4$ m/sec to roughly circularize the orbit. OMS maneuver four, a retro $\Delta V = -39$ m/sec, occurs at a latitude of 18.3-degrees south at approximately 11 hr 24 min GET. This maneuver lowers perigee to 195 km at approximately the latitude of Arecibo. The first Arecibo experiment pass occurs at approximately 22 hr 33 min GET (12 p.m. local time) with the Orbiter flying directly over the tracking facility in a southwest to north east direction remaining visible above the local horizon for about 6 minutes. At next perigee, approximately 1 hr 33 min later, the fifth OMS $\Delta V = -85$ m/sec for deboost, occurs at approximately 166 hr 15 min GET.

4.1.1.1 Throughout the mission, drag makeup ΔV maneuvers are required using the Orbiter RCS. The amount of each ΔV is highly dependent on the Orbiter altitude history. Since the tracking, orbit determination for precise drag compensation on a revolution by revolution basis is very high, a nominal ΔV will be added every few revolutions based on ground based and/or TDRSS. With a worst case attitude during the entire mission, the total makeup ΔV would be no more than 6 m/sec.

4.1.1.2 Shuttle launch time will be approximately 10 p.m. to support the Arecibo experiment pass at 12 p.m. Arecibo local time.



EVENT	TIME (GET) HR:MIN	V M/SEC	ORBITAL CHARACTERISTICS		INC DEG
			H _P (KM)	H _A (KM)	
1 ET SEPARATION THROUGH INSERTION	00:11	70	104	302	52.9
2 TRANSFER TO PHASING ORBIT ALTITUDE	0:46	64	307	330	52.9
3 CIRCULARIZE AT PHASING ORBIT ALTITUDE	1:29	6.4	320	340	52.9
4 LOWER PERIGEE FOR 1ST ARECIBO OVERFLIGHT	11:24	-39	195	329	52.9
5 TRIM PERIOD FOR 2ND-6TH ARECIBO OVERFLIGHTS	22:33	-34	187	222	52.9
6 DEORBIT	166:15	-85	—	—	—

Figure 4.1.1-1. An Orbit Sequence Has Been Chosen Which Meets All Scientific Objectives

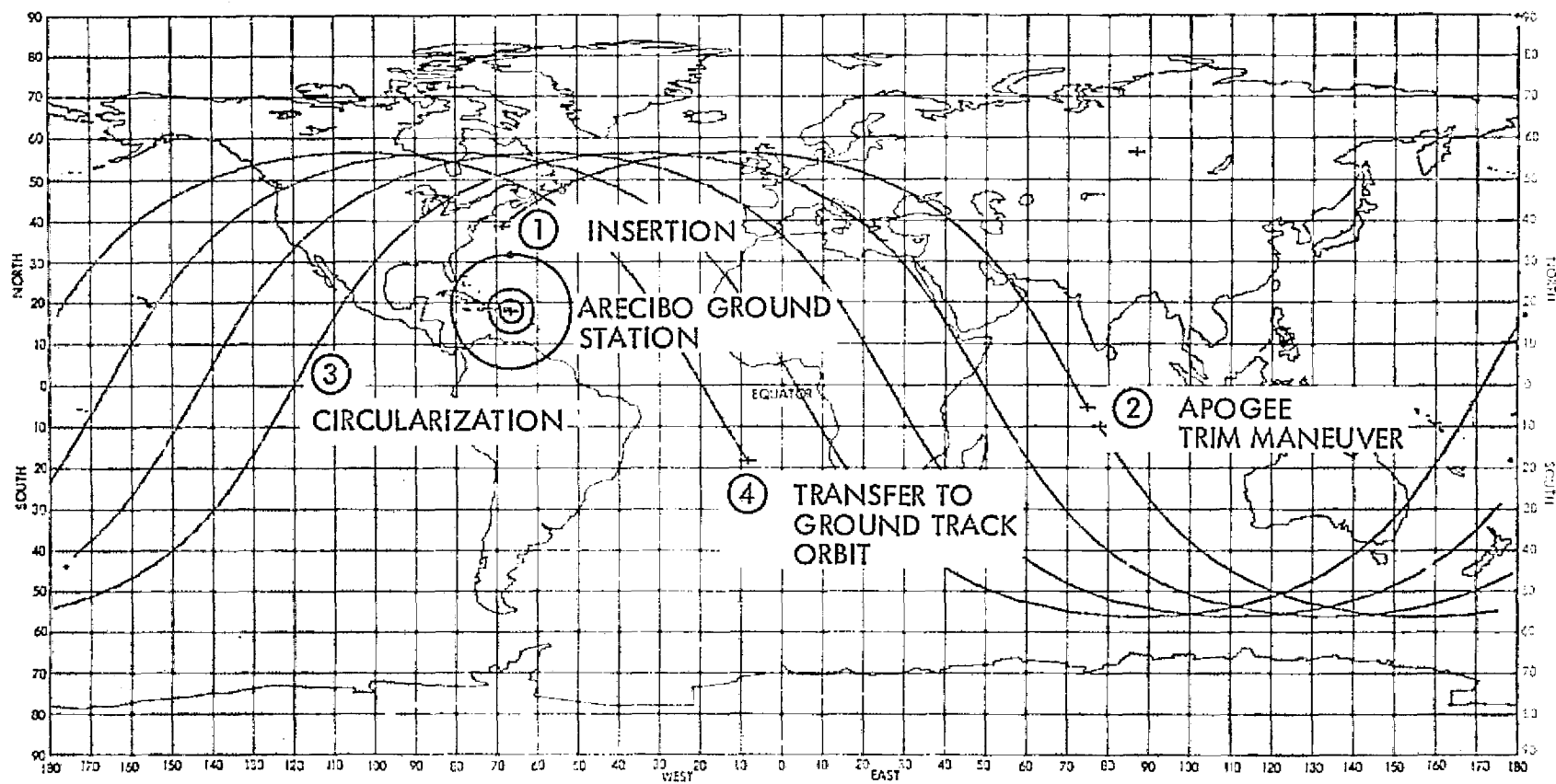
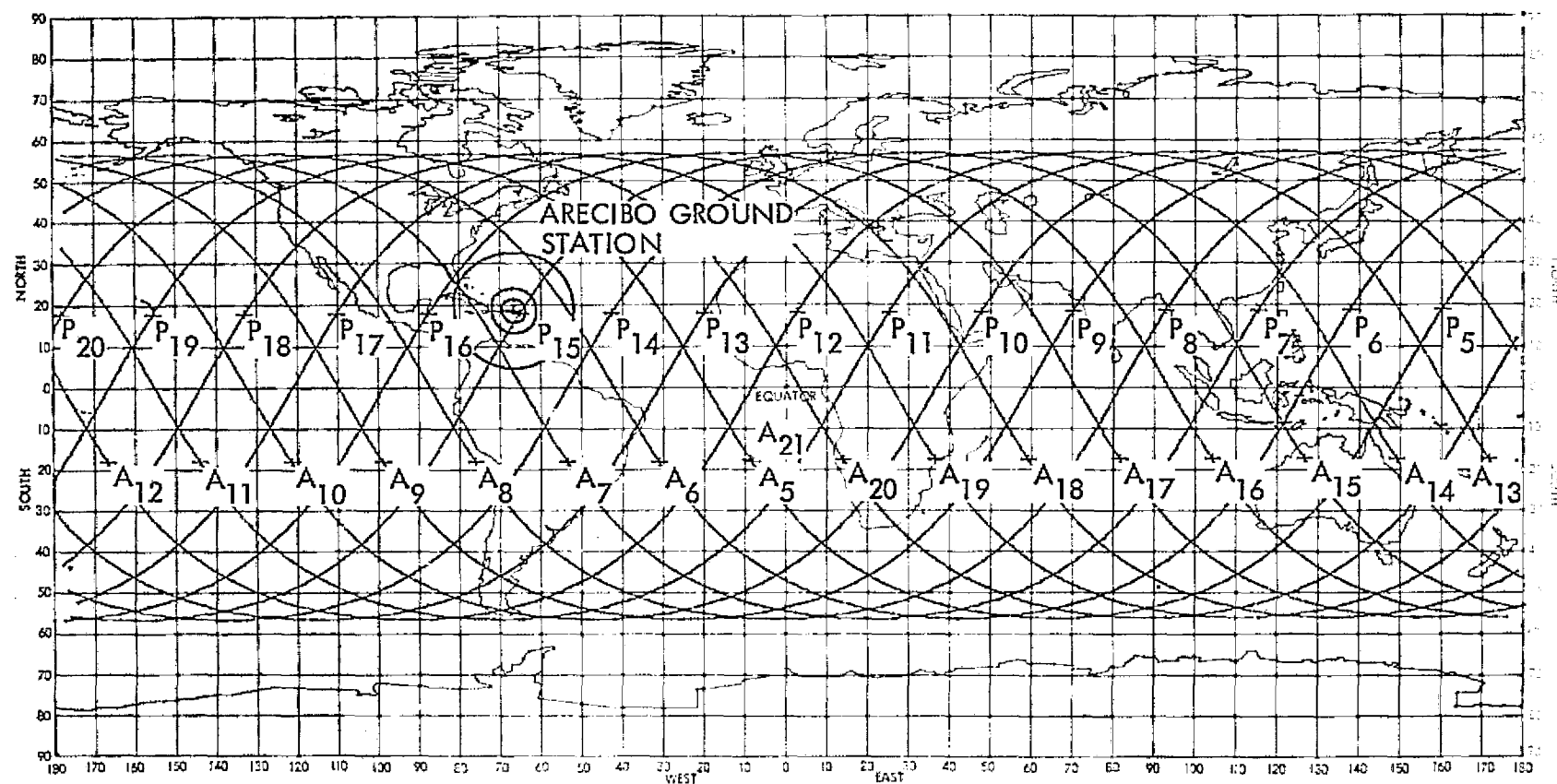


Figure 4.1.1-2. Ground Tracks During Initial Maneuvers



ARECIBO PASSES OCCUR ON ORBITS 15, 31, 47, 63, 79, 95

Figure 4.1.1-3. Ground Tracks Repeat Over Arecibo Every 24 Hours for 5 Days

4.1.2 Flight timeline. The experiment operations and scientific flight crew timeline is shown in Figure 4.1.2-1. Each of the experiments is performed independently of the others with the exception of the electron accelerator and environmental measurements. These activities are conducted using some common equipment (RMS, ESP). They have been scheduled so that accelerator experiments are conducted during dark orbital periods and the environmental measurements are made during light phases. Payload Specialist No. 1 is prime for these experiments and is supported by the Mission Specialist. Payload Specialist No. 2 is prime for the ozone density and minor constituents experiments.

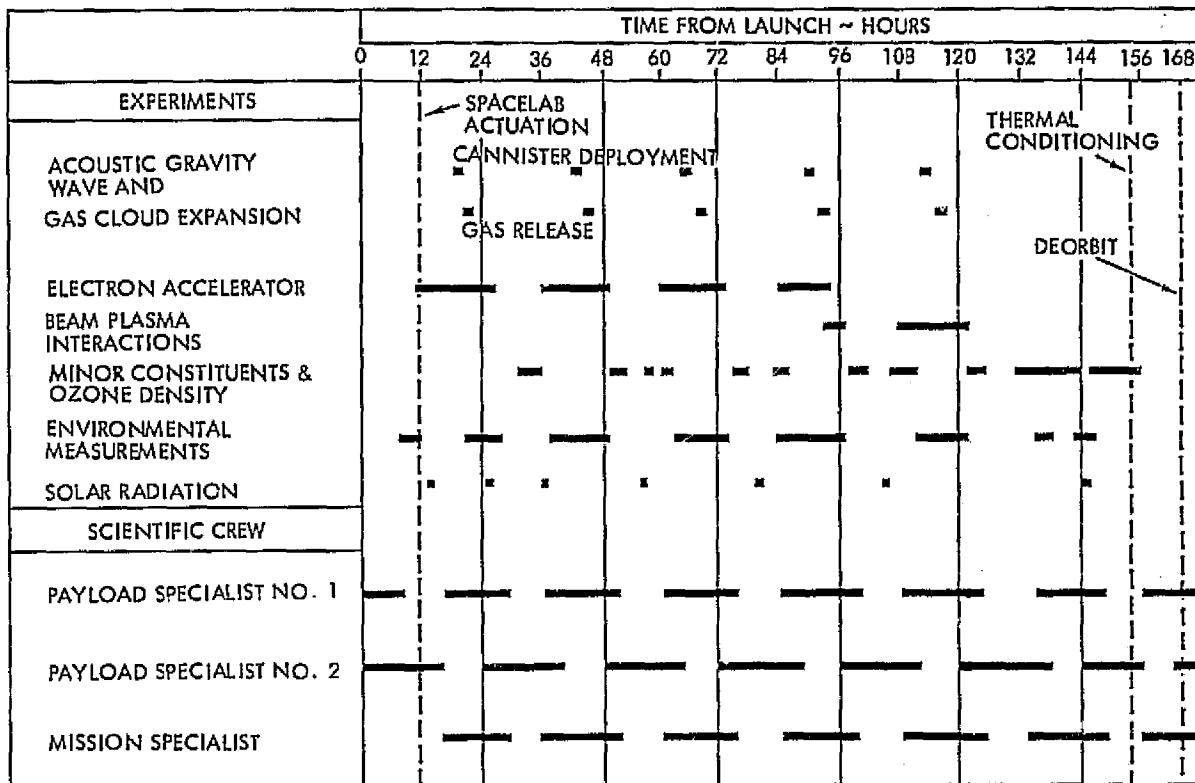


Figure 4.1.2-1. Experiment Operations and Scientific Flight Crew Timeline

4.2 SPACELAB/ORBITER RESOURCE REQUIREMENTS

4.2.1 Electrical power. The electrical power and distribution subsystem for Shuttle payload missions do not require the design of an electrical power source because power is provided from a dedicated power source in the Orbiter through the Spacelab power distribution system. No changes are required to the existing system. A review of the electrical power and energy requirements for Flight 1 resulted in power and energy values within the capabilities provided. A comparison of the capabilities and requirements are shown in Table IV.II.I-1.

The sustaining power available for the short module and three pallet segment Spacelab configuration as reported in the Spacelab System PDR-A is 3.4 kW with a peak of 7.4 kW. The total energy available is 369 kWh. The sustaining power requirement for Flight 1 in Table IV.II.I-1 is maximum sustaining power but not required over the total mission. A large margin of energy is available. A detailed review was done of the specific AMPS Flight 1 timeline and instrument power requirements, and the resulting power and energy requirements profile are shown in Figure 4.2.1-1.

Table IV.II.I-1. AMPS Flight 1 Electrical Power and Energy Requirement

	Capability	Requirement Flight 1
Sustaining (kW)	3.4	3.0
Peak (kW)	7.4 15 min, max/3 hr	3.2
Energy (kWh)	369	194

4.2.2 Thermal control. The thermal control subsystem encompasses those elements which control and maintain the temperature of the AMPS scientific payload. An overall view of the scientific payload with the thermal control system in place is shown in Figure 4.2.2-1. Multilayer insulation blankets with silvered Teflon exterior surfaces surround the instruments to minimize temperature transients and heat losses. Electric heaters are utilized for standby temperature control and reduction of instrument gradients. Maximum use

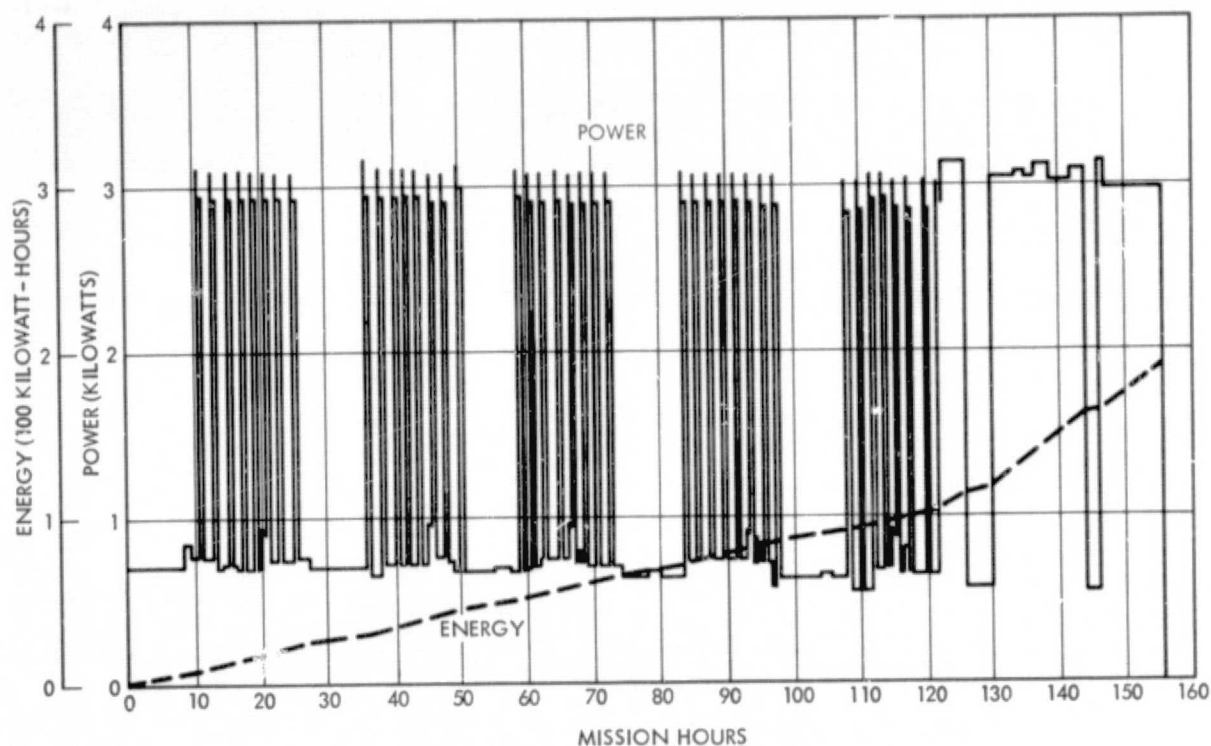


Figure 4.2.1-1. Flight 1 Payload Power and Energy Profile

is made of Spacelab provided multilayer insulation blankets for the pallet areas, avionics air cooling for module-mounted equipment, and the active pallet Freon cooling loop are included. Additionally, the SIPS standard heat pipe canister is used for pointed instrument thermal control. With the thermal control system presented, all instrument temperature requirements are met. One of the major elements of the thermal control subsystem is the special canister required to support the cryogenically cooled limb scanner. This instrument presents a major design challenge in the areas of cryogenic fluid selection, instrument design and cryogenic fluid handling techniques under the safety requirement of the Space Transportation System. Baseline to our system is the selection of solidified hydrogen for detector cooling and gaseous nitrogen/solidified nitrogen for optics cooling. The hydrogen and nitrogen are kept solidified prior to launch by a service dewar of liquid helium mounted on the pallet. Provisions also exist for a safe return of any unused hydrogen in an abort from orbit mode.

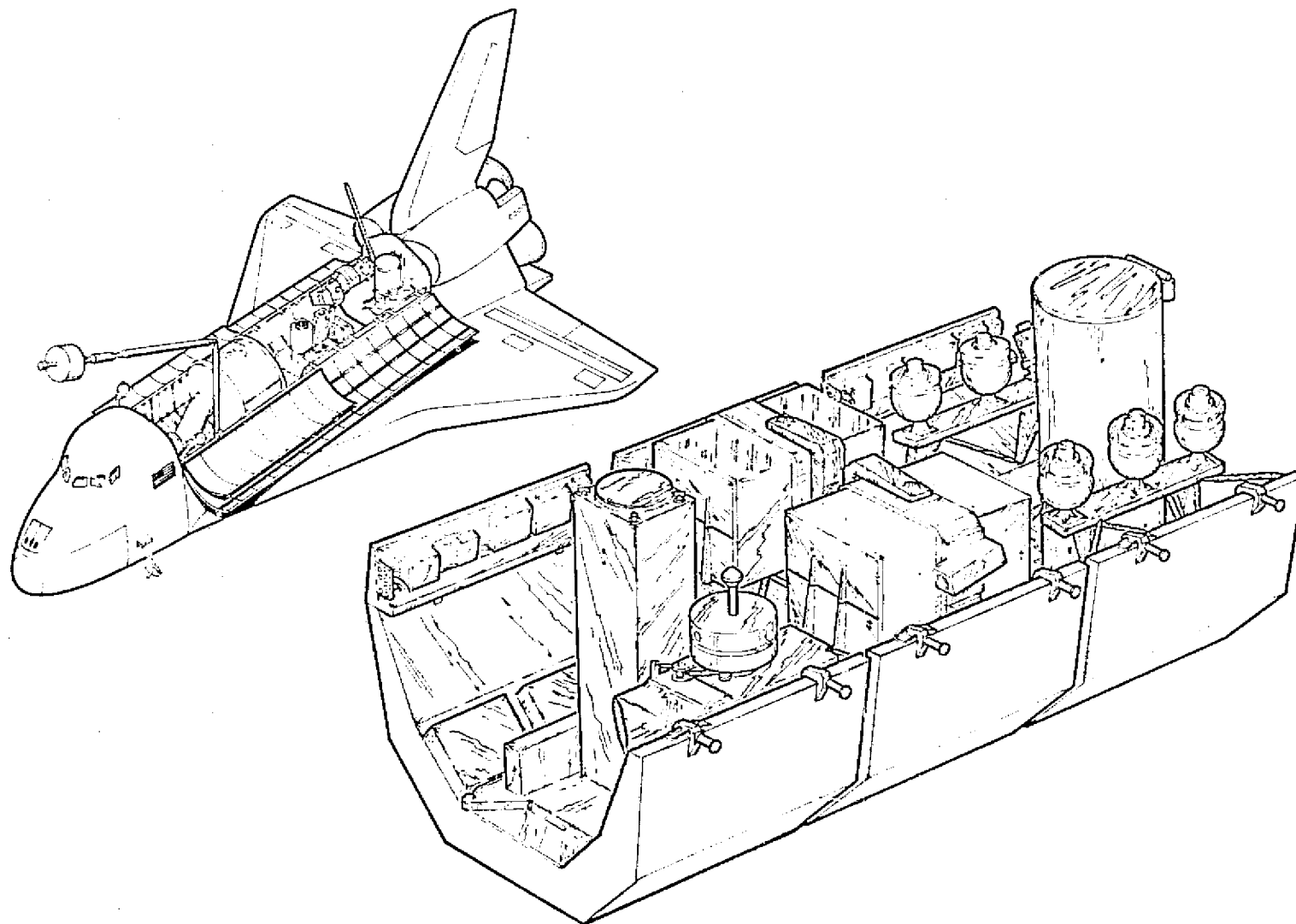


Figure 4.2.2-1. AMPS Thermal Control System Flight 1

4.2.2.1 Standby heater requirements. As pointed out earlier, heaters are utilized in some cases to maintain the lower temperature limit and the power for this technique is summarized in Table IV.II.II-1. This section is for information only since the electrical power requirements shown in Table IV.II.II-1 have been included in the electrical requirements specified in 4.2.1.

Table IV.II.II-1. Instrument Standby Power Requirements

Instrument	Maximum Standby Heat Requirement (watts)
Electron accelerator	62
SIPS system	--
Vector magnetometer	4
LIDAR	82
Gas release canister	20 each
ESP	23* each
Common energy storage	9

*0.36 M² White Strip

4.2.2.2 Active cooling requirements. The configuration of the Spacelab-provided active cooling loop and the instruments serviced by it are shown in Figure 4.2.2-2. The heat dissipated into the active Spacelab cooling loops was determined from the thermal analysis and is shown in Table IV.II.II-2.

Table IV.II.II-2. Heat Dissipated Into the Active Cooling Loop

Instrument/Assembly	Peak Cold Plate/Heat Exchanger Requirements (watts)	Orbiter Cooling Capacity (watts)
Pallet		
Common energy units	98	2000 (2 plates)
Electron accelerator	116	1000 (1 plate)
LIDAR	1991	2000 (2 plates)
Module		
Avionics HX	920	4510
Maximum	2151	5200 Total

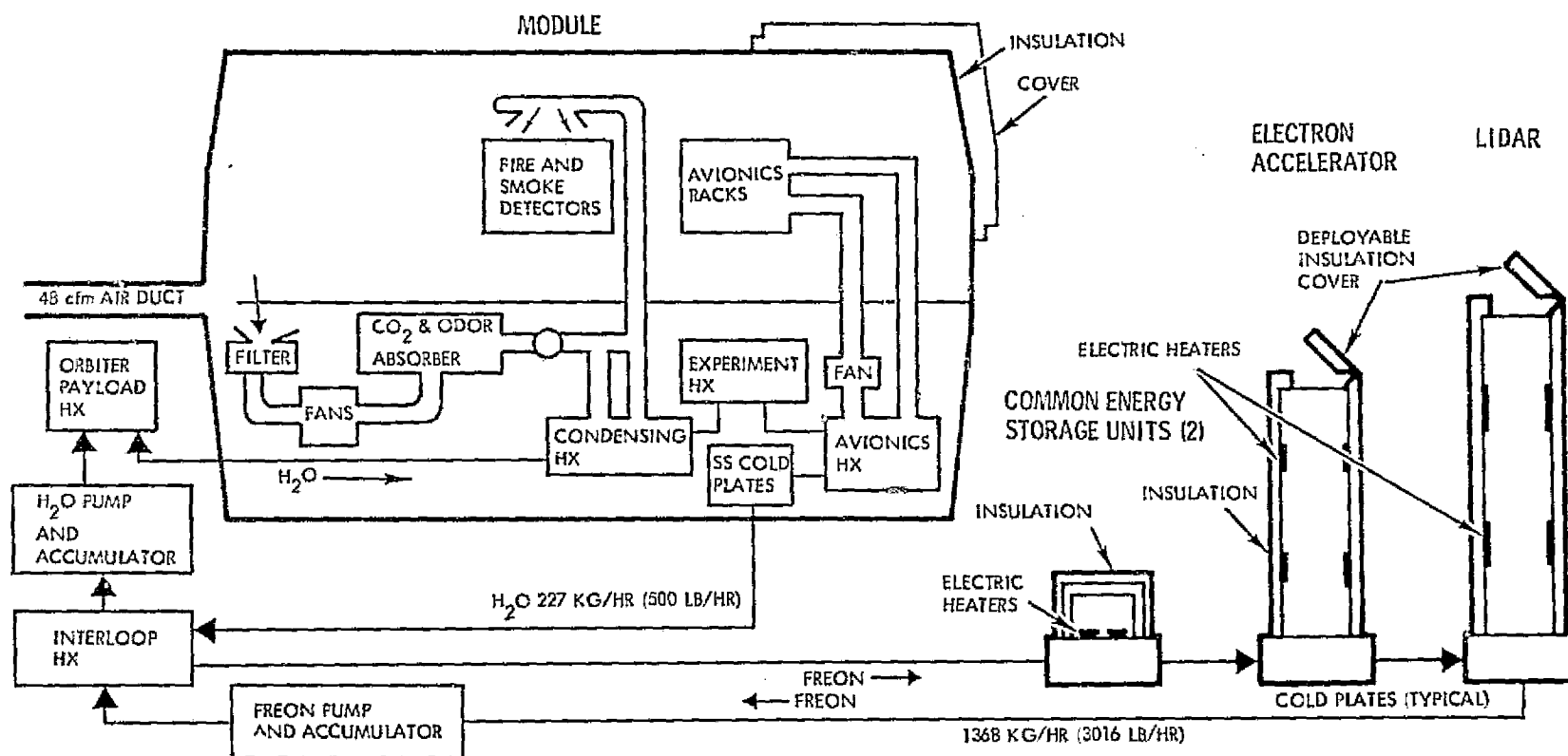


Figure 4.2.2-2. Spacelab Active Control System

4.2.2.3 Cryogenic instrument accommodation. For AMPS, the cryogenic instrument must be capable of raster scanning above the earth's horizon and it is desired that it be capable of looking at different segments of the horizon. For this reason, it has been mounted on a SIPS standard gimbal platform. An open loop cooler utilizing solid hydrogen for cooling the detector and a system using gaseous helium and solidified nitrogen for cooling the optics was the most suitable. The gaseous helium was circulated around the optics and then recooled by a heat exchanger located within the solidified nitrogen bottle. However, since hydrogen in the wrong concentration with oxygen is an inflammable mixture, precautions must be taken to prevent the presence of hydrogen while in the atmosphere. This is accomplished prior to launch by the use of a service dewar of liquid helium mounted on the pallet. The system is sized to give a 24-hour launch pad contingency capability. After SIPS deployment, this connection is severed. The cryogenic fluid handling system is shown in Figure 4.2.2-3 with an identification of the required ground system AGE.

4.2.3 Data handling. The Spacelab Command and Data Management Subsystem (CDMS) is used to accommodate the AMPS payload data acquisition and handling requirements. The AMPS science instrument data handling requirements for Flights 1 and 2 range from a few hundred bits per second to several megabits per second. However, no additional data handling support equipment is needed above what is provided by the Spacelab CDMS for AMPS Flight 1.

4.2.3.1 AMPS Flight 1 configuration. The specific configuration of the Spacelab CDMS to accommodate the AMPS Flight 1 data handling requirements is shown in Figure 4.2.3-1. Orbiter/Spacelab data handling interfaces and the RAU placement necessary for command distribution and data collection on AMPS Flight 1 is also shown in Figure 4.2.3-1.

- (a) Commands to the Spacelab CDMS can originate from three sources. These are from the ground via the Orbiter General Purpose Computer (GPC), preprogrammed on-board commands that are stored in the Spacelab computers, and adaptive commands that are interactively generated in real time using the Spacelab CRT/keyboard. The ground commands are sent from the Orbiter GPC to the Spacelab I/O units via the GPC/MDM/I/O unit interface. All of these types of commands are distributed to the appropriate I/O unit, data bus, and finally to the proper RAU and instrument.

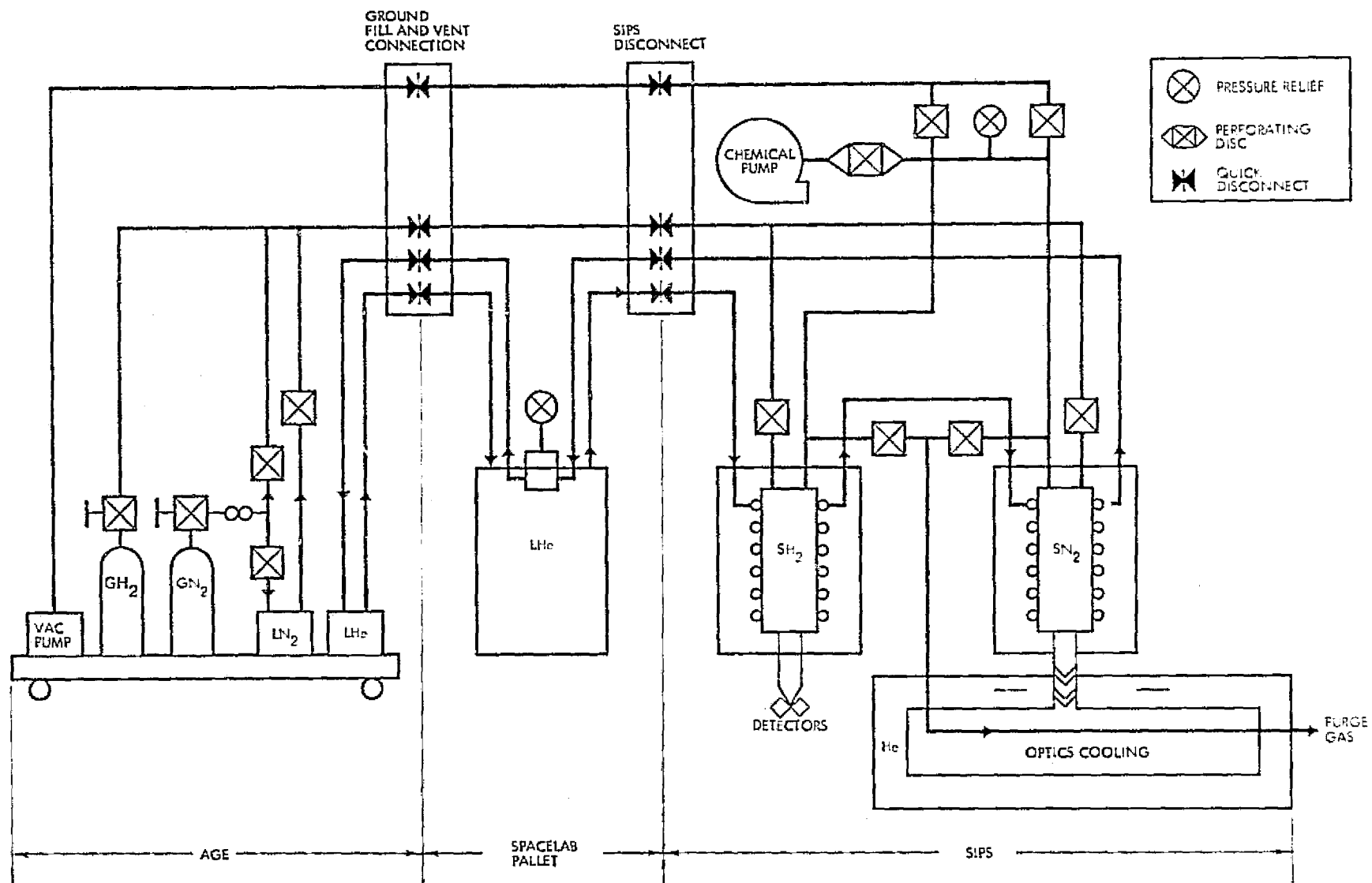


Figure 4.2.2-3. Cryogenic Fluid Handling System

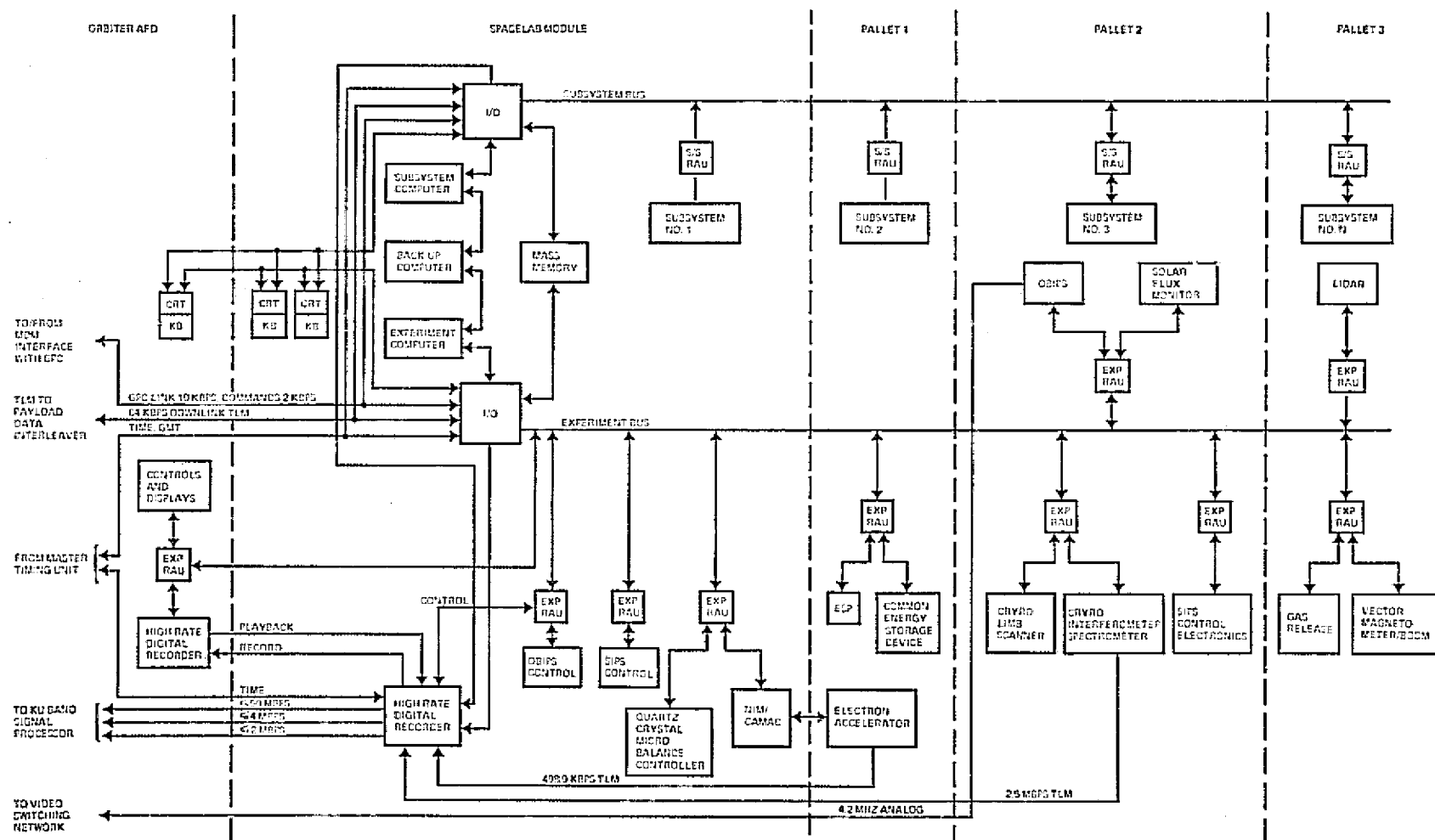


Figure 4.2.3-1. AMPS Flight 1 Data Handling Flight Subsystem Configuration

- (b) Low rate telemetry is acquired via the subsystem and experiment data bus with the RAU's interfacing directly with the instruments for data acquisition. The low-rate science and engineering data processed by the computers can be displayed on CRT's and/or used by the computers for limit checks. The low-rate data is also transmitted to the ground through the Orbiter Payload data interleaver via the S-band or the Ku-band communication equipment.
- (c) Medium rate science data from the subsystem or experiment I/O units and high rate data from the electron accelerator and the cryro interferometer/spectrometer instruments are accepted by the high rate multiplexer (HRM) for transmission to the ground or are recorded for later playback through the HRM. The HRM interfaces directly with the Ku-band signal processor which is part of the Ku-band communication equipment on the Orbiter.
- (d) Detailed review of the instrument command and data handling requirements has been accomplished. For each instrument, the number and types of commands, and the science and status data requirements have been identified.
- (e) In all cases, the utilization of each experiment RAU is 75 percent or less for all types of inputs and outputs. Consequently, the configurations shown here have substantial growth capability if the data requirements increase when the instruments become better defined.

4.2.3.2 Data preprocessing. Some science instruments, such as the LIDAR, generate large blocks of science data. A mini-computer or processor is teamed with the Spacelab computer to preprocess and condense the raw science data prior to entering the science data onto the Spacelab data bus. Without preprocessing, over 30×10^6 bits of data are generated each time the LIDAR is fired. With preprocessing, only 3.1×10^3 bits of data are presented to the Spacelab data bus. The electron accelerator is augmented with NIM/CAMAC equipment, which contains a data processor, and the LIDAR is augmented with a data processor (mini-computer), within the instrument, to reduce the data processing requirements on the Spacelab computer.

4.2.3.3 Environmental sensor package data handling configuration. The environmental sensor package (ESP) is a free-flyer type of satellite launched from the Shuttle cargo bay and is part of the AMPS payload. The science instruments on board the ESP will utilize the Orbiter Payload interrogator subsystem to provide the necessary command and telemetry links. Via this link, the Orbiter is capable of commanding at a 2-kbps rate, and receiving telemetry data at 16 kbps. The ESP's will require essentially the same complement of science instruments for both Flights 1 and 2. The ESP will consist of seven science instruments. For Flights 1 and 2, all seven instruments are not required to be active during any one experiment. Therefore, the instruments can be grouped for operation in two different modes; i.e., Mode 1 and Mode 2 operation. The grouping of the instruments into two modes of operation will permit the best utilization of the Orbiter payload interrogator data link and still remain within the total 16 kbps maximum data rate. The active instruments for Mode 1 operation are:

- (1) Medium energy electron detector
- (2) DC electric field
- (3) E and B receivers
- (4) Vector magnetometer
- (5) Langmuir probe.

The active instruments for Mode 2 operation are:

- (1) Ion mass and distribution analyzer
- (2) Neutral mass spectrometer
- (3) Vector magnetometer
- (4) Langmuir probe.

Figure 4.2.3-2 shows the ESP data handling configuration that permits maximum science data return.

4.2.3.4 Data formats. Flight 1 consists of seven individual experiments. The synthesis of data formats that is compatible with the payload is highly dependent upon the mission operation and flight timeline. Due to the large number of instruments and experiments, a different format for each situation is undesirable. At the same time one format capable of satisfying all the instruments would waste valuable transmission bandwidth. Therefore a solution that is between these extremes has been selected.

- (a) The data handling requirements on an experiment basis are presented for Flight 1 in Table IV.II.III-1.

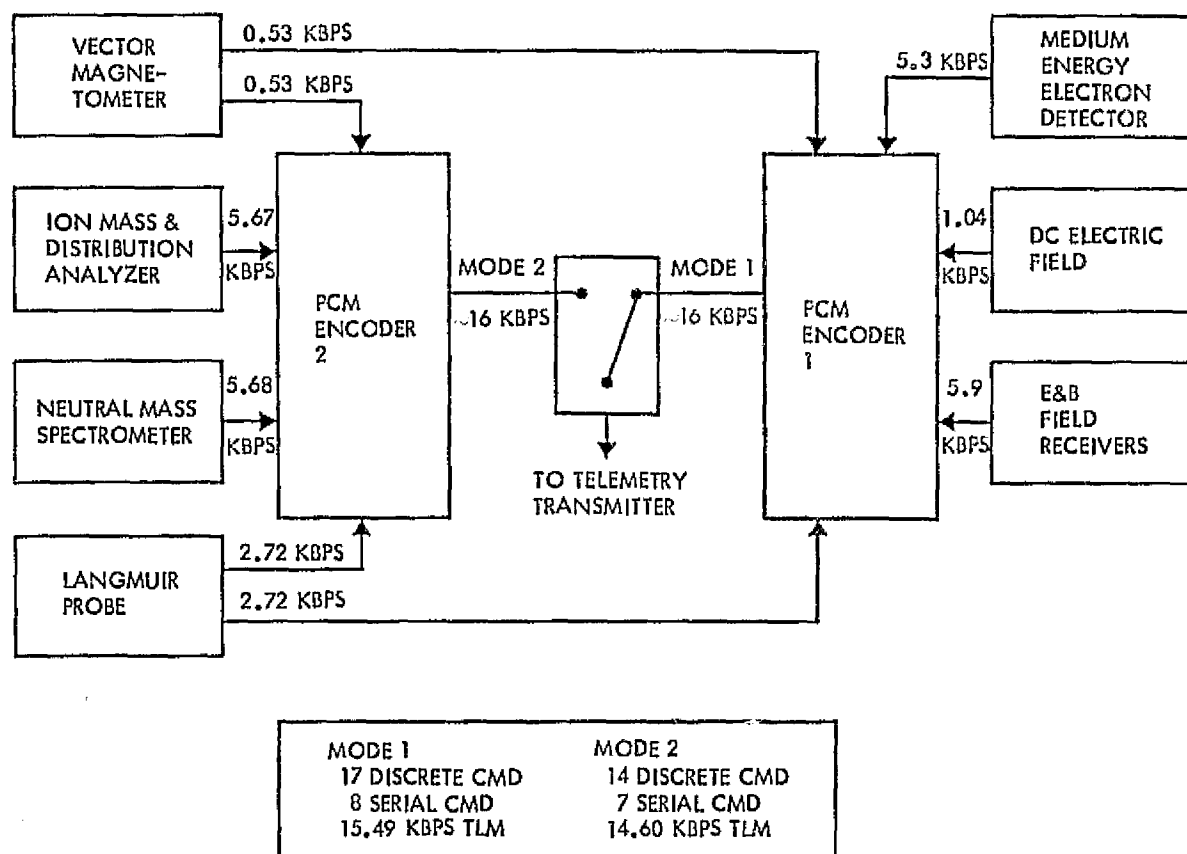


Figure 4.2.3-2. ESP Data Handling Configuration

Examining these data handling requirements, Flight 1 can be accommodated with two digital formats and one analog format. The data format requirements for Flight 1 are shown in Table IV.II.III-2.

- (b) For Flight 1, two digital formats are required; i.e., 1A at 2.6 mbps and 1B at 536 kbps. Format 1A is capable of supporting any one of the high data rate experiments (Acoustic Gravity Wave, Gas Cloud Expansion, or the Minor Constituent experiments) plus the low data rate Environmental Measurements and Solar Flux Radiation experiments simultaneously. Format 1B is capable of supporting one of the medium data rate experiments (Electron Accelerator or Beam Plasma Interaction) plus the low data rate Environmental Measurements and Solar Flux Radiation experiments. Format 1C is used to accommodate the video signal that is generated by the OBIPS in support of certain experiments.

Table IV.II.III-1. Data Handling Requirements for Flight 1

Experiment	Maximum Data Requirements		Comments
	Digital	Analog (MHz)	
Acoustic Gravity Wave	2.51 mbps	4.2	Analog is video signal generated by the optical band imager
Gas Cloud Expansion	2.51 mbps	4.2	
Electron Accelerator	516.0 kbps	4.2	
Beam Plasma Interactions	516.0 kbps	4.2	
Minor Constituents	2.56 mbps		Highest data rate
Environmental Measurements	16.7 kbps		
Solar Flux Radiation	3.2 kbps		Performed 30 minutes once per day

Table IV.II.III-2. Flight 1 Experiment Data Format Requirements

Experiments	Format No.		
	1A (2.6 mbps)	1B (536 kbps)	1C (4.2 MHz)
1) Acoustic Gravity Wave	X		X
2) Gas Cloud Expansion	X		X
3) Electron Accelerator		X	X
4) Beam Plasma Interaction		X	X
5) Minor Constituents	X		
6) Environmental Measurements	X	X	
7) Solar Flux Radiation	X	X	

4.2.4 Software. This section describes the software functions that must be performed in support of the AMPS Flight 1 payload by:

- (a) The Orbiter computers and master timing unit
- (b) The Spacelab subsystem computer.

4.2.4.1 Orbiter computer support.

- (a) Remote manipulator control. The remote manipulator (RMS) is needed to position the AMPS ESP package. This positioning is carried out under the control of Orbiter GPC computer software. Where the RMS conducts a scanning or other type of motion during an experiment, direct quantitative RMS relative position feedback to the experiment monitor console display is required for data interpretation purposes. This relative position data will also be downlinked. Where a fixed-preplanned position is maintained by the RMS during the experiment, direct quantitative relative position feedback to the experiment monitor console display is desirable but not required. Table IV.II.IV-1 identifies the RMS support requirements as required by several Flight 1 experiments.
- (b) ESP telemetry support (optional). ESP telemetry will be collected at a rate of 16 kilobits per second. The path taken by the data through the Orbiter data handling system has not been conclusively established and may involve the GPC computer in coordinating this data transfer. Table IV.II.IV-1 shows for which experiments the 16 kbps Orbiter support is required.
- (c) Orbiter orientation control. All experiments planned for Flight 1 require Orbiter orientation. The maintenance of this orientation is under the control of Orbiter computer software. Table IV.II.IV-1 identifies the Orbiter orientation requirements for each experiment. The most complex requirement arises where the Orbiter +Z axis is to be kept aligned with the local magnetic field. (Electron accelerator experiments.) In spite of relatively low accuracy requirements, this is a sufficiently complex problem so that direct digital transfer of the required Orbiter orientation angles from the Spacelab experiment to the Orbiter computers is required. The required Orbiter response is to orient the Orbiter within the vehicles' capabilities to the requested orientation.

Table IV.II.IV-1. Orbiter Computer Software Support Requirements

Experiment	Orbiter RMS Control Required via GPC	Orbiter Orientation Control Required	Orbiter Telemetry Support Required
Vehicle neutralization	Fixed position	+Z along local magnetic field	Yes
Beam characteristics	Fixed position	+Z along local magnetic field	Yes
Beam plasma interactions	Scanning mode	+Z along local magnetic field	Yes
Acoustic gravity wave	-	SIPS instruments to survey gas cloud	-
Gas cloud expansion dynamics	-	SIPS instruments to survey gas cloud	-
Minor constituents	-	SIPS instruments to limb scan from 20 to 100 kilometers altitude	-
Ozone density	-	+Z axis pointed to Nadir	-
Environment measurements	Scanning mode	Vary +Z axis with respect to velocity vector	Yes
Solar radiation	-	SIPS solar radiation monitor to view the sun	-

4.2.4.2 Time and state vector. The AMPS Flight 1 mission software needs timing and Orbiter state vector information (as defined in the Spacelab Payload Accommodation Handbook), that is transmitted from the Orbiter to the experiment computer.

4.2.4.3 Spacelab subsystem information. Where the subsystem computer can turn power or thermal units on or off, the experiment computer must "know" the on/off status of resources supplied to the payload equipment to enable proper performance of its experiment monitoring and control tasks.

4.2.5 POINTING AND CONTROL. The major pointing and control requirements placed on the Spacelab and Orbiter is for an experimental pointing mount. This requirement results from the fact that a large number of the instruments included in the AMPS payload require either: 1) a large field of view or motion relative to other body fixed instruments, 2) fine pointing to accuracies better than Orbiter can provide (i.e., approximately 2 degrees) or rate stabilization over selected periods better than Orbiter can provide (i.e., approximately $0.01^{\circ}/\text{sec}$).

4.2.5.1 Many NASA studies have shown that the most cost effective way to meet these requirements is with an independently gimballed pointing mount. These experiment pointing mount requirements are not unique to AMPS and have been recognized by NASA for general payload support. As a result, preliminary work has been done on several designs and a decision on which EPM design to support is planned by NASA. The most likely candidate appears to be the small instrument pointing system (SIPS) which forms the basis of the baseline design.

4.2.6 Stowage. The Orbiter/Spacelab stowage requirements for the AMPS Flight 1 payload are as shown below.

Item	Number of Units	
	Core Segment	AFD
Work bench containers	1	-
Ceiling stowage containers	2	-
Rack stowage containers	0	-
Loose equipment temperature storage (trash disposal bag)	2	-

4.2.7 OMS/RCS propellant usage. The OMS and RCS propellant usage is based on the attitude changes and maneuvers required for orbital operations and the pointing required for each experiment. Requirements are summarized below.

	RCS (kg)	OMS (kg)
Capacity	3353	11377
Utilization		
• Nominal	1829	9814
• Dispersions	136	
• Reserves		591
• Unavailable	366	256
Total	2331	10661
Margin	1022	716
% Margin	34	7

- 4.2.8 Controls and displays. The Orbiter/Spacelab controls and displays required in support of the AMPS Flight 1 payload are provided below.

Item	Number of Units	
	Core Segment	AFD
Orbiter		
CRT and keyboard		1
C&W panel		1
CCTV	1	2 (split screen)
RMS C&D		1
Spacelab		
EPDS Monitor and Control	1	1
ARS D&C panel	1	
CRT and keyboard	2	1
Integration control panel (R-7)		1
Master intercom	1	
Remote intercom	2	

4.3 SPACELAB/ORBITER INTERFACE REQUIREMENTS. This section describes the analyses, tests, test results, hardware, software, and other supporting data which is required to show payload compliance with Spacelab/Orbiter interface requirements for contamination, electromagnetic compatibility, and safety.

4.3.1 Contamination. The demands for a clean operating environment derive primarily from the Orbiter and Orbiter crew and from the payload experiment apparatus. The general requirements are specified in Section 4.3 of NASA document JSC-07700, Volume XIV, Space Shuttle System Payload Accommodations, in Section 7.11 of NASA/ESA document SLP/2104, Spacelab Payload Accommodation Handbook, and in NASA document GSFC-TBD, Labcraft Payload General Specification.

4.3.1.1 Analyses. Payload contamination sources for pallet-mounted equipment were identified and tabulated as shown in Table (TBS). A simple line-of-sight analysis[see Appendix (TBD)] established the accretion and impingement of contaminants on Orbiter and Spacelab surfaces as well as on other payload equipment.

4.3.1.2 Testing. All payload materials which do not have historical data on off-gassing and outgassing characteristics must be subjected to tests either in a laboratory or on an early shuttle flight. The source of contamination data and/or test results on payload materials is presented in Table (TBS).

4.3.1.3 Design. The flight 1 design includes specific design features dictated by cleanliness requirements. These are:

- (c) Special covers on the SIPS canisters, the electron accelerator, and the lidar.
- (b) The incorporation of cold traps at heaters as required.

4.3.1.4 Inspection and cleaning. All AMPS payload equipment will be inspected under both white and ultraviolet light for visible contamination, cleaned if necessary, and maintained clean throughout the integration process. The requirements for integration facilities and for personnel engaged in payload integration are defined in (TBD), and are basically compatible with the class 100,000 cleanliness requirements specified in Section 4.3 of JSC-07700, Volume XIV.

4.3.1.5 Handling, packaging, and transportation. Payload equipment handling, packaging, and transportation technique must be selected and designed to preserve the cleanliness requirements as noted in 4.3.1, above. The specific

measures taken to preserve equipment cleanliness are delineated in Table (TBS).

- 4.3.1.6 Ground support equipment. All Labcraft GSE destined for use in any controlled integration area must be designed, cleaned, tested, or otherwise processed to prevent it from contaminating the integration area. Table (TBS) lists the procedures necessary to process various Labcraft GSE prior to use in a contamination-controlled environment.
- 4.3.2 Electromagnetic compatibility (EMC). The Flight 1 payload has been designed, fabricated, and integrated to comply with the EMC requirements specified in NASA document JSC SL-E-002, MIL-STD-461A Space Shuttle Amendment, Electromagnetic Interference Requirements, Equipment, in JSC 07700, Volume XIV, Space Shuttle System Payload Accommodations, and in the (NASA)/ESA document SLP/2104, Spacelab Payload Accommodation Handbook. Details on the actions taken to satisfy these requirements are outlined in the Labcraft EMC Control Plan.
- 4.3.2.1 Analysis. A computer-assisted compatibility analysis was conducted on the Flight 1 payload. The problem areas identified during this analysis and the actions taken to alleviate those problems listed in Table (TBS).

In addition to the above, an analysis was made of potential interference due to high magnetic and electric fields or due to high energy particles originating in the Flight 1 instruments. The results of these analyses are summarized in Tables (TBS).

- 4.3.2.2 Design. The following design practices have been implemented on the Flight 1 payload to improve its EMC characteristics:
- Equipment housings electrically bonded per MIL-B-5087, Class R
 - Housings designed as RF tight enclosures
 - In-line, passive EMI filters at all power interfaces
 - Fully shielded electrical cable harnesses
 - Primary power returns electrically isolated from structure, secondary power, and signal returns
 - No intentional power or signal return currents in structural members
 - Single-point grounding for all circuits except coaxial RF circuits

- All I/O circuitry protected against indirect lightning strike and spacecraft differential charging/discharge effects.

Exceptions to the above design practices and justification for these exceptions are listed in Table (TBS).

- 4.3.2.3 Testing. A number of tests were conducted on individual items of flight and ground equipment and on the integrated (level IV) payload. The results of these tests, as well as the test procedures and the test equipment used, is contained in Technical Report (TBS). All waivers and deviations to approved test requirements are listed in Table (TBS).
- 4.3.3 Safety. The Flight 1 payload has been designed to comply with the requirements of NASA document NHB-XX entitled Safety Policy and Requirements For Payloads Using the National Space Transportation System. The methodology and approach used to satisfy these requirements is defined in the AMPS Safety Plan.
 - 4.3.3.1 Analysis. A detailed analysis of the Flight 1 payload design was made to identify potential hazard sources and to institute actions to delete or alleviate such hazards. The remaining or residual hazards were then subjects of a risk analysis and the results of this activity are summarized in Table (TBS).
 - 4.3.3.2 Material Review. All materials used in the Flight 1 payload have been reviewed to insure compliance with established safety requirements are identified in Table (TBS).
 - 4.3.3.3 Testing. A number of tests were conducted on various materials and components (e.g. pressure vessels) to establish compliance with safety standards. These tests, along with test results, are listed in Table (TBS).
 - 4.3.3.4 Caution and Warning (C & W). The Flight 1 payload includes certain components which are dedicated to alerting the crew to impending hazardous conditions or which are capable of rendering a hazard inert. Figure TBS is an electrical schematic showing these components and their interface with the Orbiter/Spacelab C & W system. Table (TBS) lists the various parameters being monitored and the safety category of each parameter.

4.4 COMMUNICATION AND DATA REQUIREMENTS. The communication and data handling subsystem shall provide to the payload all the services necessary for instrument command and control, data acquisition, data processing, data formatting, data displaying, data storing, and data transmission to the ground. Maximum use of the Shuttle Orbiter communication equipment and of the Spacelab Command and Data Management Subsystems shall be made.

4.4.1 Real time downlink data. Real time low rate downlink data consisting of payload housekeeping and engineering data shall be transmitted via the Orbiter S-band or Ku-band communications equipment at a normal data rate of 64 kbps. Medium and high rate data shall be acquired via the Spacelab high rate multiplexer (HRM). The HRM will interface with the Ku-band signal processor. Real time medium and high rate data will be available only during periods of TDRSS coverage via the Orbiter Ku-band communication subsystem. Flight 1 experiments shall require two data formats at 2.6 Mbps and 536 kbps. For real time data transmission, only one of these transmission rates need be supported at any one time.

4.4.2 Uplink commands. Uplink commands sequenced at a 2 kbps information rate shall be transmitted via the STDN S-band, or relayed via TDRSS S-band or Ku-band. From the communication subsystem, the Orbiter network signal processor (NSP) routes the commands to the Orbiter general purpose computer (GPC). The commands are finally sent to the Spacelab subsystem or experiment computer (via the multiplexer/demultiplexer and the Spacelab I/O units) for execution.

4.4.3 Stored and dumped data. During periods when TDRSS coverage is not available, housekeeping and payload data shall be recorded on the Orbiter maintenance PCM recorder for later playback when TDRSS coverage is available. Medium and high rate data shall be recorded on the Spacelab high rate digital recorder (HRDR) during TDRSS outage periods. Minimum tape record capability shall be not less than 60 minutes at the data rates specified in 4.4.1 to span the TDRSS non-coverage periods with one Ku-band antenna. When TDRSS coverage is available, the recorded data can be dumped through the HRM at a maximum rate of 32 Mbps from the HRDR. Playback data and real time data shall be capable of being multiplexed together for a combined maximum data rate of 50 Mbps.

4.4.4 Voice and TV data. Payload voice data (maximum of six duplex analog voice channels) shall be routed between the Spacelab master intercom unit via the Orbiter audio central control unit. Only two fully duplexed voice digital channels are available through the Orbiter communication subsystem to the ground. These voice channels shall be shared

between the Orbiter crew and experimenters. During periods when TDRSS coverage is not available the voice data is recorded on the Orbiter PCM maintenance recorder for later playback. TV signals shall be routed from the Spacelab CCTV feedthrough to the video switching network for distribution. The video switching network shall interface with the Ku-band signal processor for transmission to the ground via the Ku-band TDRSS equipment. The composite video signal shall not exceed 4.5 MHz in bandwidth and must be compatible with EIA standards RS170 and RS330.

- 4.4.5 TDRSS requirements. TDRSS shall provide S-band and Ku-band communication coverage for the Flights 1 and 2. S-band communications shall be used only to establish Ku-band communications. The nominal operational mode of communications shall be via the Ku-band communications subsystem. High rate science data (approximately 2.6 Mbp/s) experiments will be conducted for approximately 60 hours during a 7-day mission. Nominally this data will not be required in real time in total, and TDRSS access time can be reduced by recording the data at 2.6 Mbps and dumping the data down at a 32 Mbps rate. This represents more than a factor of 10 reduction in actual TDRSS access time if all of the data is recorded and dumped at the 32 Mbps rate. However, the actual high rate TDRSS access time will be highly dependent on the mission timeline and mission operations somewhere between the two extremes given above. However, housekeeping and voice data (low rate data) will be required to be transmitted through TDRSS almost on a continual basis throughout the 7-day mission.

- 4.4.6 DOMSAT requirements. The DOMSAT usage required by AMPS is described below.

Experiment	Data Rate mbps	Maximum Time per Event (min)	Number of Events	Total Usage min	Allowable Delay
Acoustic gravity wave	2.51	10	5	50	TBD
Minor constituents	2.6	720	8	3510	TBD

4.4.7 On-board data processing. This section describes the functions performed by the on-board AMPS flight software application programs servicing the first mission. Table IV.IV.VII-1 presents these requirements.

4.4.8 Post-flight data processing. The required post-flight data processing of the experiment data will consist of:

- (a) Frame synchronization
- (b) Time correction/correlation
- (c) Event status
- (d) Error detection
- (e) Calibration
- (f) Grouping
- (g) Conversion to engineering units
- (h) Formatting

The details of these requirements are TBD.

4.4.9 Data distribution. The distribution of experiment data will include:

- (a) Storage in the POC for remote access
- (b) Distribution of computer compatible tapes
- (c) Distribution of reports.

The details of these requirements are (TBD).

Table IV.IV.VII-1. Flight 1 Equipment and Experiment Data Processing Software Requirements

LABCRAFT EQUIPMENT AND EXPERIMENTS	FUNCTIONS									
	Receive Keyboard Commands	Number of Instrument Controls	Number of Graphical Displays Required	Tabular Displays Required	Calibration Displays Required	Science Processing Required	HRM Control Required	Special Sequencing or Safety Checks	Receive Uplink Commands	Computer Supported Experiment Calibration and Control Parameters
<u>Instruments and FSE</u>										
Gas release	Yes	5	0	1		(1)			Yes	Yes
Vector magnetometer		2	1	1						
Electron accelerator		21	3	1		(2)				
Level I diagnostics		4	0	1						
Level II diagnostics		33	4	2						
Lidar		16	2	1	TBD					
OBIPS		10	0	1						
IR radiometer		6	2	1	TBD					
IR interferometer spectrometer		10	2	1	TBD	(4)				
Quartz crystal microbalance		6	1	1						
SIPS		12	3	1		(5)				
Common energy storage		6	0	1				(7)		
Mast adapter		3	0	1				(6)		
Environmental sensor package		25	6	1	TBD					
Solar flux monitor	Yes	4	1	1			Yes		Yes	Yes
<u>Experiments (17)</u>										
Vehicle neutralization	Yes			1	(18)		Yes	(3)	Yes	(9)
Beam characteristics				1	(13)			(3)		(10)
					(18)					
Beam-plasma interactions				1	(13)			(3)		(11)
					(18)					
Acoustic gravity wave					(14)			(3)		(15)
Gas cloud experiment dynamics					(14)			(3)		(15)
Minor constituents				1	(19)					(16)
Ozone density								(3)		
Environment measurements				6	(12)					(20)
Solar radiation	Yes				(8)		Yes		Yes	Yes
(1) Safety processing (2) Beam orientation with respect to magnetic field (3) Firing sequencing, special monitoring (4) Sun avoidance computations (5) Kalman filter processing and star map referencing (6) Energy band processing for medium energy detector, interference rejection for E&B receivers, telemetry stream. Processing for environmental package processing (7) Mast safety check (8) Candidate for automatic operation under computer control (9) Vary beam characteristics (10) Vary accelerator energy, currents, and focus settings and preserve these settings for subsequent use (11) Vary accelerator energy, currents, and focus settings and preserve these settings for subsequent use. (12) Geometric computations required to determine relative position of RMS (13) Geometric computations for beam orientation and Orbiter orientation requests (14) Geometric computations for line-of-sight orientation of SIPS and for canister ejection initialization (15) Commanded angles for Orbiter orientation and SIPS pointing (16) Commanded orientation angles for Orbiter (17) In the experiment category, only significant experiment functions that are over and above those served by individual instrument and FSE packages are called out (18) Compute Orbiter orientation with respect to local magnetic field (19) TBD geometric computations to assure proper Orbiter orientation for limb scanning operation (20) Vary Orbiter orientation.										

5. PAYLOAD GROUND REQUIREMENTS

5.1 SPACELAB ELEMENT STAGING REQUIREMENTS FOR THE PAYLOAD INTEGRATION CENTER

- 5.1.1 Mission-dependent equipment. The hardware specified in Tables V.I.I-1 and V.I.I-2 will be "staged" at KSC and transported to the Level IV integration site. Staging requirements specifically address pallets, racks, and aft flight deck hardware.

Table V.I.I-1. Pallet Staging Requirements

<u>Pallet 1*</u>	<u>Quantity</u>
Experiment RAU's	
Cold plates	
Thermal Capacitors	
Coolant plumbing	
Thermal insulation blankets	
EPDB's	
<u>Pallet 2*</u>	
Experiment RAU's	
Cold plates	
Thermal capacitors	
Coolant plumbing	
Thermal insulation blankets	
EPDB's	
<u>Pallet 3*</u>	
Experiment RAU's	
Cold plates	
Thermal capacitors	
Coolant plumbing	
Thermal insulation blankets	
EPDB's	
*Shipped to the Level IV site.	

Table V.I.I-2. Module Staging Requirements

<u>Structure</u>	<u>Quantity</u>
Single rack	2
Double Rack	4
<u>Aft flight deck</u>	
High rate data recorder	1
<u>Electrical</u>	
Experiment switching panel	6
Harnesses	TBD

- 5.1.2 Mission-independent equipment. The following hardware is allocated as mission-independent equipment and will be shipped to the Level IV site.

Hardware	Quantity
<u>Mission-independent Spacelab equipment located in Orbiter aft flight deck</u>	
Data display and keyboard	
Subsystem RAU	1
Interconnecting station	1
Power distribution bus (AFD)	1
<u>Pallet</u>	
Pallet structure	3
2.9 m pallet segments	
Structure per pallet segment	TBD
Inner panels	
Outer panels	
Freon loop plumbing	TBD

- 5.1.3 Multimission support equipment. The following hardware is allocated as multimission independent equipment. The hardware comprises portions of the small instrument pointing system (SIPS).

Hardware	Quantity
Central column includes up/down and left/right fine gimbals	1
Instrument support frame	2
Standard heat pipe thermal enclosure	1
Roll gimbal	1
Standard gyro and star tracker sensor package	1

- 5.1.4 Common payload support equipment. No common payload support equipment (CPSE) is required for AMPS Flight 1.

5.2 PAYLOAD INTEGRATION/GROUND OPERATIONS TEST

5.2.1 Payload integration. The payload integration activities consist of the tasks required to integrate and test the flight support equipment, instruments, and pallet and rack elements. The testing required at each level of assembly is shown in Table V.II.I-1. The payload integration will be conducted in accordance with the integration and test flow depicted in Figure 5.2.1-1. The tasks and time required to complete the integration is outlined in Figure 5.2.1-2.

Table V.II.I-1. Payload Integration Test Requirements

Configurations	Tests
Individual instruments Individual FSE Individual pallets Individual racks	1) Receiving and inspection consisting of a visual inspection and limited performance verification on instruments and FSE as appropriate 2) Electrical performance evaluation tests (EPET) on instrument drawers and installed electrical cables 3) Verification of RAU performance 4) Verification of EPDB and ESP performance
Single pallet element	1) EMC performance 2) Interface verification 3) Optical alignment 4) Experiment data bus performance 5) Ordnance circuitry verification 6) Instrument and experiment software package verification
Integrated system	1) Integrated system test - Verify overall electrical and mechanical performance - Verify system integrity 2) Mission operation simulation test - Mission timeline performance - Limited crew training

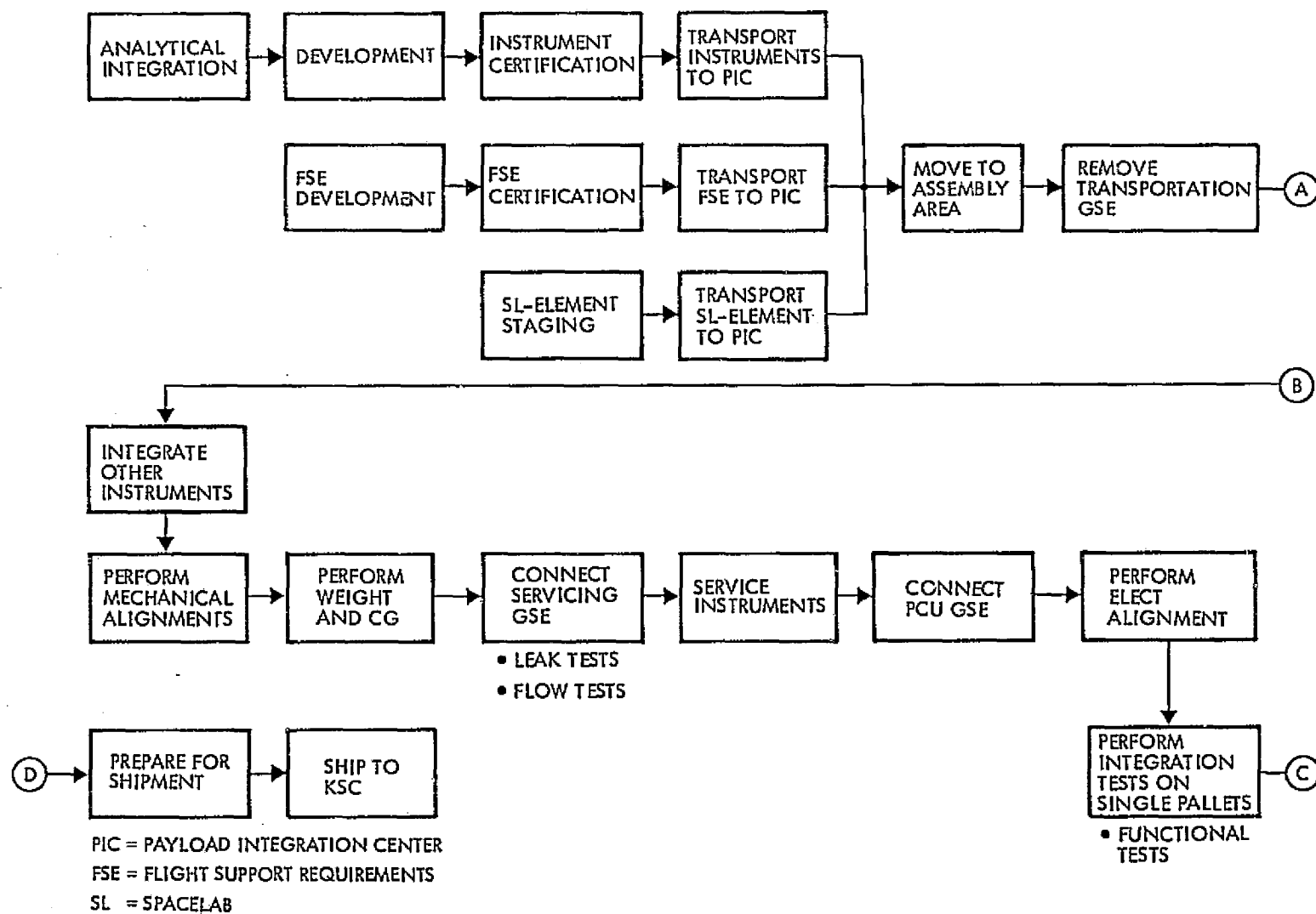


Figure 5.2.1-1. AMPS Payload Integration Flow

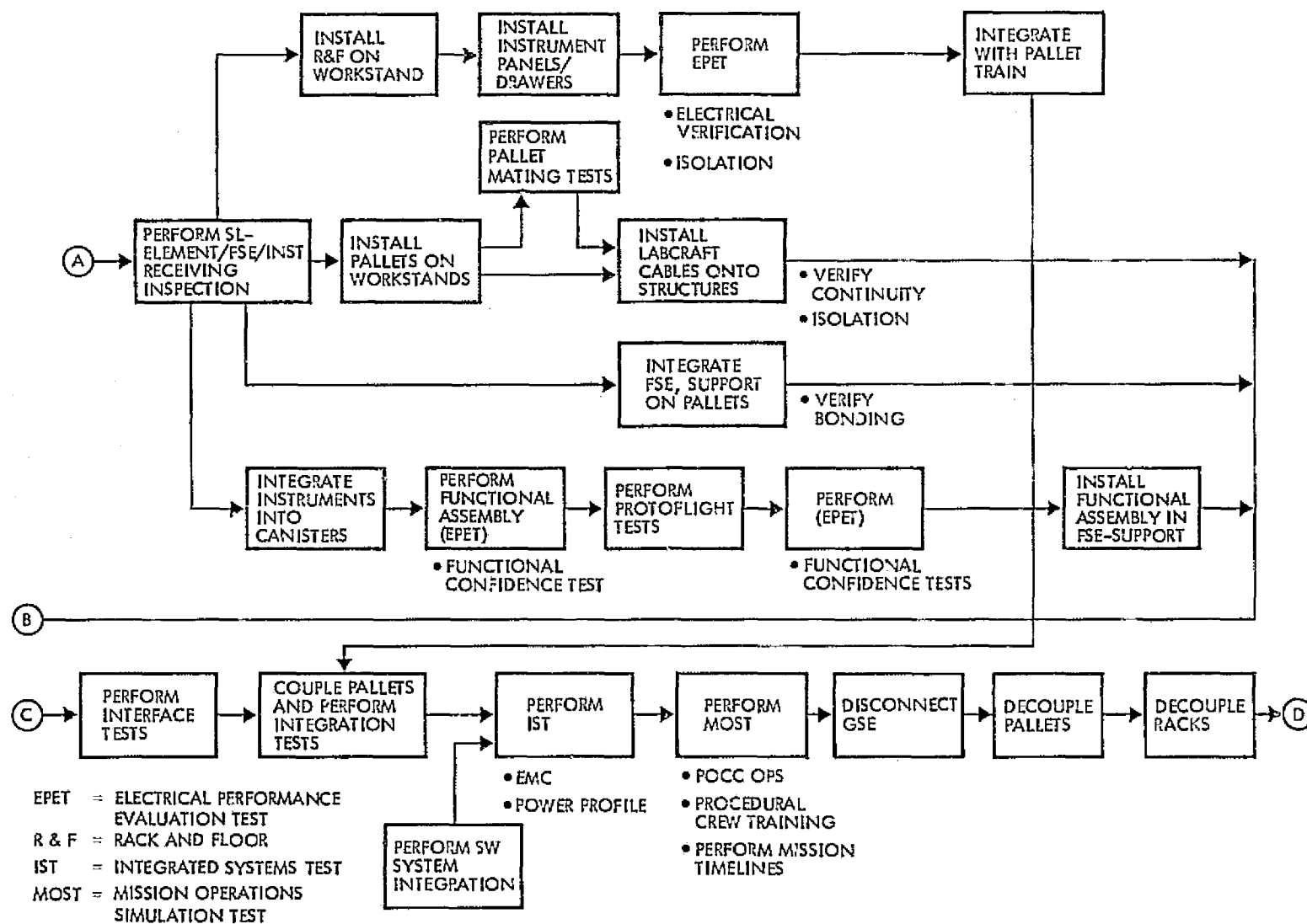


Figure 5.2.1-1. AMPS Payload Integration Flow (Continued)

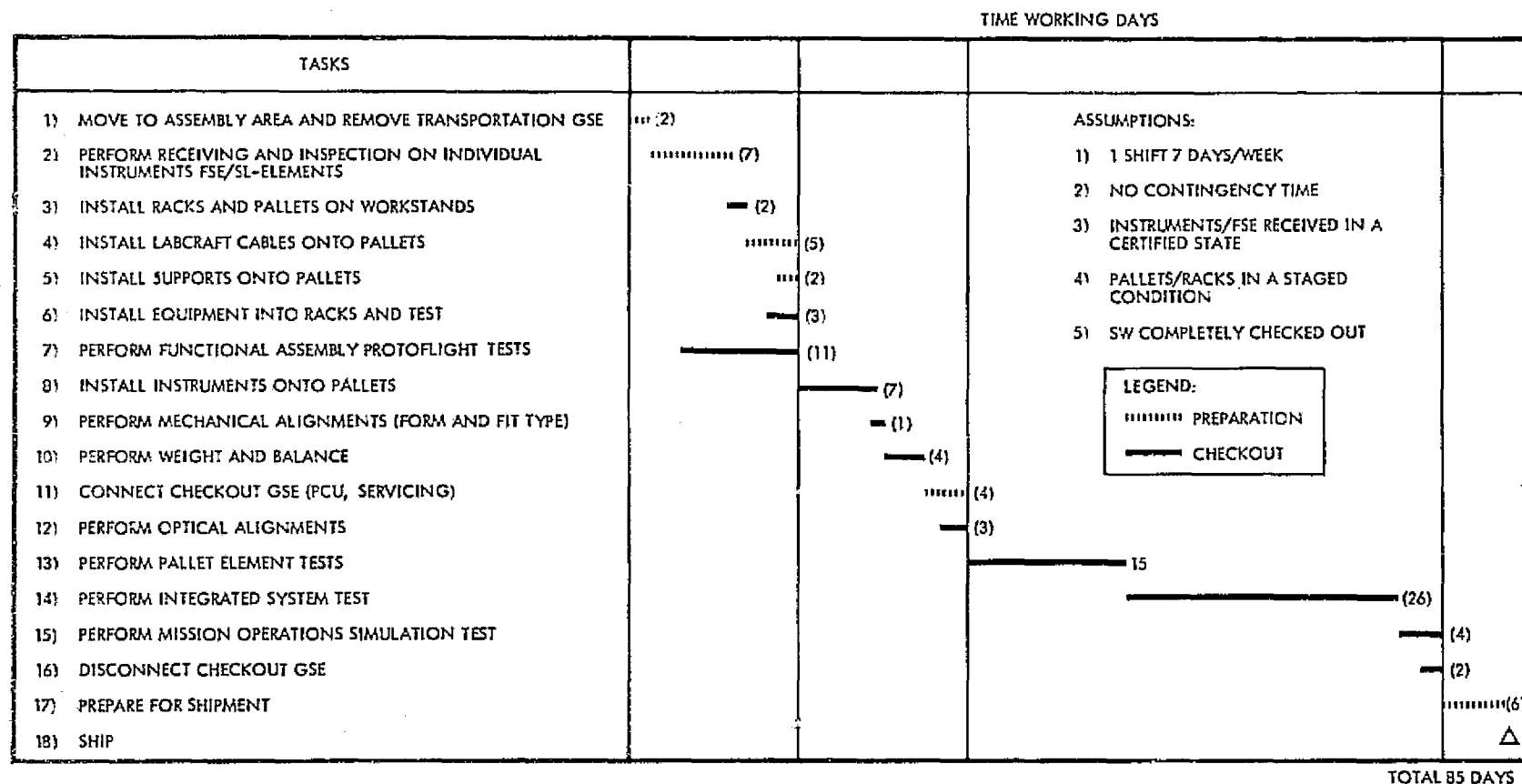


Figure 5.2.1-2. AMPS Integration Schedule

5.2.2 Ground operations. The Level IV integration contractor will provide support during the ground operations phases at the launch site. The integration phases, which are specifically supported, are specified in Table V.II.II-1 and Figure 5.2.2-1. The primary support consists of providing payload technical expertise to the integration crew during the tests conducted at the operations and checkout building and Orbiter processing facility. During the time allocated to the task of closing the payload bay at the pad, support will be provided to the SIPS cryogenic loading activity.

Table V.II.II-1. Level IV Integration Phases

Test Phase	Support Required
<u>Operations and checkout building</u>	
Instrument checkout and calibration	Test support
Instrument compatibility test	Test support/data reduction
Instrument servicing and functional test	Test support
SL simulated orbit mission segment test	Test support
<u>Orbiter processing facility, VAB, PAD</u>	
Orbiter integration tests	Test support/data reduction
Payload bay final closeout	Test support
Pad payload service	Test support
<u>Post mission</u>	
Safing operations	Test support
Data removal	Data reduction
Post mission checkout	Data reduction
Instrument removal	Test support

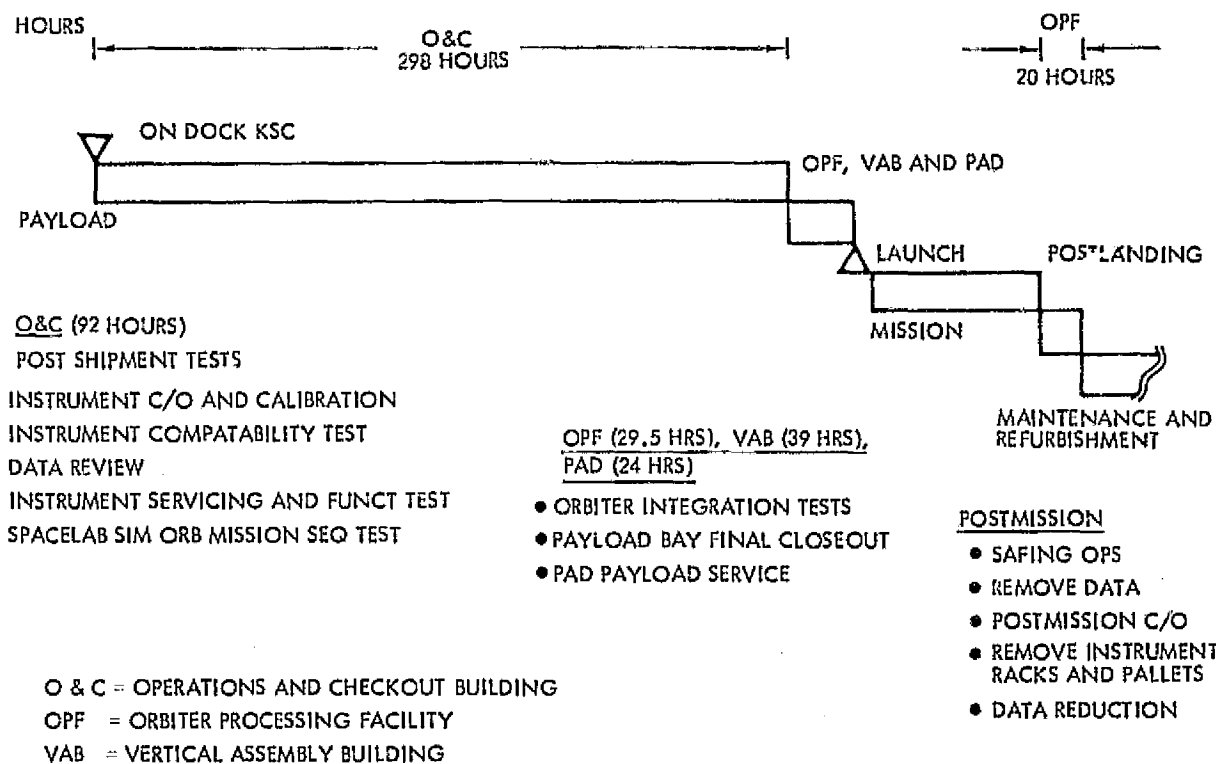


Figure 5.2.2-1. The AMPS Program will Support Ground Operations During Spacelab and Orbiter Integration and Post-Mission Activities

5.3 GSE REQUIREMENTS

5.3.1 Payload Integration Center. The GSE listed in Table V.III.I-1 is required at the Payload Integration Center (PIC) in support of Level IV integration activities.

5.3.2 Launch site. Based on the assumption that the payload integration contractor will perform an off-line post-shipment test, the GSE required at the launch site in addition to the Spacelab GSE is listed in Table V.III.II-2.

Table V.III.I-1. PIC Ground Support Equipment

Hardware	Requirements/Functions
<u>Mechanical</u>	
Pallet/rack hard mockup	Available on a schedule that supports the fabrication, test, and operational checkout schedule of the flight support equipment Designs that allow for a high-fidelity reproduction of the mechanical features of the pallets and racks Flexibility to accommodate various instrument configurations
Handling dolly	Provide in-plant mobility for a single pallet segment and a rack and floor structure A rail design capable of interfacing with the rails of the checkout stands
Pallet/rack checkout stands (five-pallet stand)	Provide a dedicated working area for pallet and rack integration Provide accessibility to the pallets and racks Design which incorporates the Spacelab rail "roll in/out" concept
Optical alignment kit	Provide the capability to perform assembly stand, instrument, pallet mating operation alignment
Thermal blanket handling kit	Provide the capability to support and protect the thermal blankets associated with the instruments and pallets during handling and hoisting

Table V.III.I-1. PIC Ground Support Equipment (Continued)

Hardware	Requirements/Functions
<u>Mechanical</u> (Cont) Labcraft payload checkout cooling unit Pallet segment floor covers (15 per kit) Rack and floor installation and removal kit Pallet segment support X-ray unit FSE positioning aids Weight and balance kit Cleaning kit	Provide cooled dehumidified air to the rack-mounted experiments Perform the functions of draining, purging, evacuating, and circulating Freon through the pallet cold plates Provide protection to the pallet floor during integration operations Provide support for any rack and floor assembly combination when on the assembly stand Support the pallets empty or full during all integration and transportation activities Perform the functions of determining internal malfunction, stress, or corrosion in small connectors or small metallic components Assist in the removal and installation of hardware components weighing over 20 kg Perform weight and center of gravity determination. The kit will be used in conjunction with the sling kits. Perform unscheduled and scheduled cleaning of exterior payload/Spacelab element surfaces
<u>Electrical</u> AMPS payload checkout unit	Monitor, distribute, and control the power required for the individual or integrated experiment testing Provide control, display, and realtime monitoring of sequenced events Provide realtime monitoring of red line conditions with capability for automatic/manual shutdown through the hardwire safing commands

Table V.III.I-1. PIC Ground Support Equipment (Continued)

Hardware	Requirements/Functions
<u>Electrical (Cont)</u>	
AMPS payload checkout unit (Cont)	Provide communication links with the experiment and subsystem RAUs Process and display in "real time" emergency caution and warning signals Provide recording capability for wideband analog and digital experiment data Provide automatic control of the experiment coolant and heating and monitor in real time Provide timing signals (GMT and MET) and sync signals for experiment events Provide interface capability for experiment-unique GSE Provide interface capability for the Payload Operations Control Center
Ordnance tester	Verify ordnance firing commands and circuitry Verify "no voltage" status of ordnance circuits prior to the installation of live ordnances
Aft end cone adapter	Provide the aft end cone to pallet electrical and fluid physical interface bulkhead
Electrical harnesses	Provide electrical harnesses from the PCU to the pallet elements and/or pallet train
Continuity tester	Perform continuity tests on AMPS electrical cables
Grounding/bonding tester	Verify the bonding compatibility of the equipment after installation
EMC test equipment	Verify electromagnetic compatibility between instruments

Table V.III.II-2. Launch Site Ground Support Equipment

Hardware	Requirements/Functions
<u>Mechanical</u> FSE positioning aids Thermal blanket handling kit <u>Electrical</u> AMPS payload checkout unit	Assist in the removal and installation of hardware components weighing over 20 kg Provide the capability to support and protect the thermal blanket associated with the instruments and pallets during handling and hoisting Monitor, distribute, and control the power required for the individual or integrated experiment testing Provide control, display, and realtime monitoring of sequenced events Provide realtime monitoring of red line conditions with capability for automatic/manual shutdown through the hardware safing commands Provide communication links with the experiment and subsystem RAUs Process and display in "real time" emergency caution and warning signals Provide recording capability for wideband analog and digital experiment data Provide automatic control of the experiment coolant and heating and monitor in real time Provide timing signals (GMT and MET) and sync signals for experiment events Provide interface capability for experiment-unique GSE Provide interface capability for the Payload Operations Control Center

Table V.III.II-2. Launch Site Ground Support
Equipment (Continued)

Hardware	Requirements/Functions
Ordnance tester	Verify ordnance firing commands and circuitry Verify "no voltage" status of ordnance circuits prior to the installation of live ordnances
Electrical harnesses	Provide electrical harnesses from the PCU to the pallet elements and/or pallet train

- 5.4 FACILITIES AND SERVICES. Facilities and services are required at both the Payload Integration Center (PIC) and the launch site. These facilities shall provide for storage, assembly, and checkout of the AMPS payload.

5.4.1 Facilities. A pictorial description of the AMPS PIC is shown in Figure 5.4.1-1. The facility will provide storage, assembly, and office space as shown in Table V.IV.I-1. Launch site facilities will be required to store, maintain, and inspect the AMPS payload. The launch site facility requirements are shown in Table V.IV.I-2.

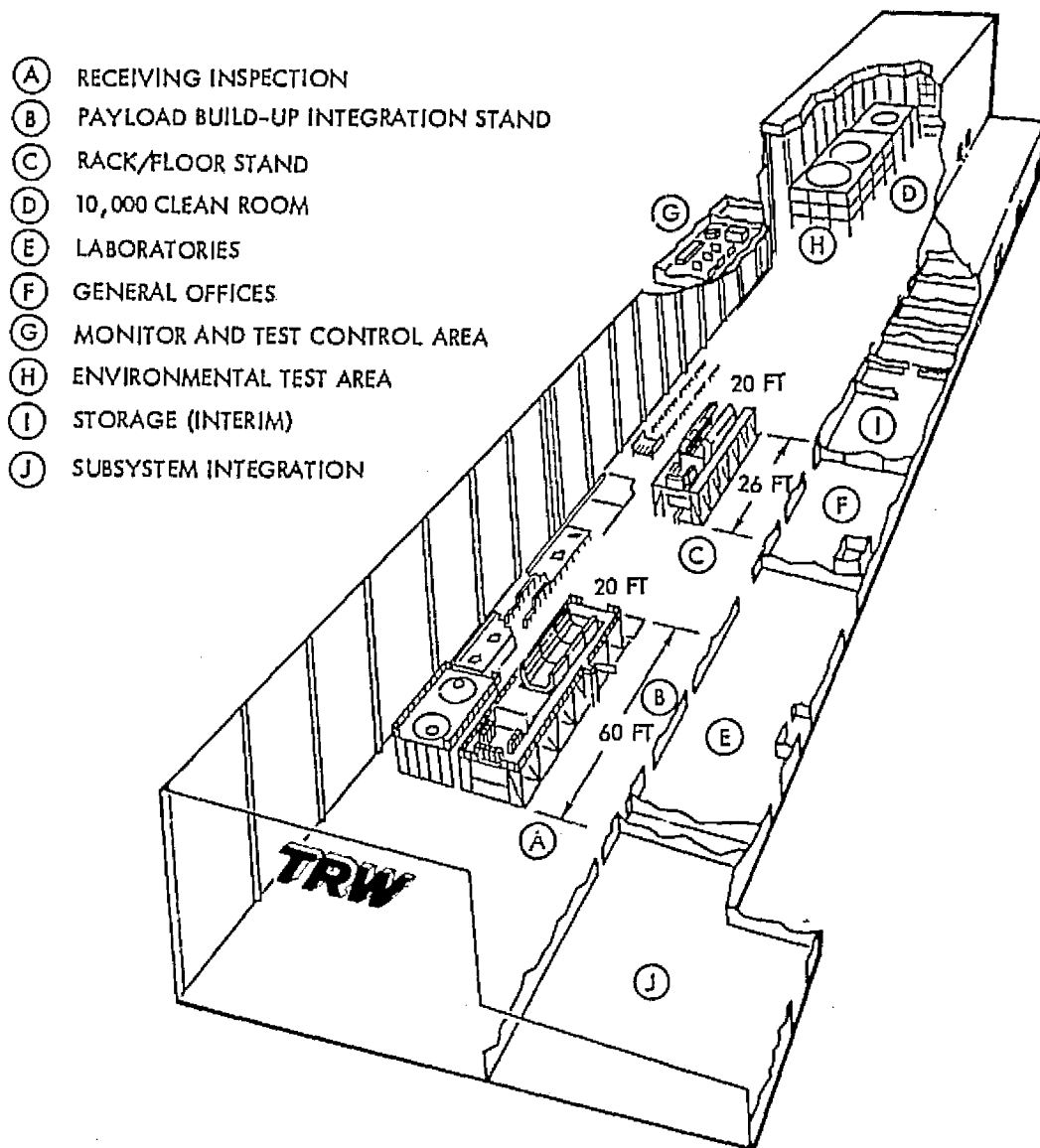


Figure 5.4.1-1. Payload Integration Facility

Table V.IV.I-1. PIC Requirements

Functions	Area (M ²)
Receiving inspection	(TBD)
Payload build-up integration stand	(TBD)
Rack/floor stand	(TBD)
10,000 clean room	(TBD)
Laboratories	(TBD)
General offices	(TBD)
Monitor and test control area	(TBD)
Environmental test area	(TBD)
Storage (interim)	(TBD)
Subsystem integration	(TBD)

Table V.IV.I-2. Launch Site Facility Requirements

Function	Area (M ²)
Receiving inspection	(TBD)
Spares	(TBD)
Instrument GSE	(TBD)

5.4.2 Services. The PIC and launch site shall provide the following services for the AMPS flight:

Temperature	75°F Max.
Humidity	<50% (Rel. Hum.)
Cleanliness	100K, 10K
GN ₂	TBD
GO ₂	TBD
GH ₂	TBD
Missile Grade Air	TBD
Shop Air	TBD
H ₂ O	TBD
Freon	TBD
28 Vdc Reg/Non-Reg.	TBD
120 V, 60 Hz Single Phase	TBD
120/208 V, 60 Hz Three Phase	TBD
110/220 V, 60 Hz Single Phase	TBD
Overhead Cranes	Height Capability (TBD)

5.4.3 Post-mission processing. The post-mission processing requirements are (TBD).

5.5 LOGISTICS

5.5.1 Payload integration center. The logistic requirements necessary to support functional assembly proto-flight certification, pre-Level IV and Level IV integration and maintenance of AMPS equipment at the Payload Integration Center are as follows:

Function	Support
Support and test equipment	Test equipment required to support AMPS integration and maintenance activities are identified in Table (TBS). All test equipment shall conform with applicable calibration requirements. Current calibration records shall be maintained at the PIC.
Documentation	A library containing technical documentation on all AMPS equipment shall be established at the PIC. Technical documentation shall contain all applicable revisions to reflect actual hardware configuration. Technical documentation shall be adequate to support both integration and maintenance activities.
Maintenance	The integration and test team shall contain qualified maintenance personnel trained to perform preventive and corrective maintenance at the organizational and intermediate levels. Preventive maintenance schedules shall be established and all applicable procedures implemented to ensure maximum availability of AMPS equipment.
Spare/repair parts	A bonded storeroom shall be established at the PIC. This storeroom shall contain the level of spare/repair parts necessary to support all integration and maintenance activities performed at this location. Inventory control shall be maintained and spare/repair parts usage documented.

- 5.5.2 Launch site. This section defines the logistics requirements necessary to support AMPS equipment preflight and postflight operations.

Function	Support
Preflight logistics support	Maintenance shall consist of fault isolation to the line replaceable unit (LRU) level, removing the faulty LRU, replacing the LRU with a good spare unit, and verification procedures to ensure problem has been corrected. Spare LRU flight equipment shall be maintained at (TBD) facility. Test and support equipment required for preflight test and maintenance activities are identified in Table (TBD). Postflight consists of repair and/or refurbishment of AMPS equipment. Specific requirements concerning postflight AMPS refurbishment is contained on Document (TBD).
Personnel required	(TBD)

6. PAYLOAD FLIGHT SUPPORT REQUIREMENTS

6.1 POCC REQUIREMENTS. The AMPS Payload Operations Control Center (POCC) will be designed to complement the National Space Transportation System command, control and communications network and maximize the scientific return for each flight. The POCC will provide facilities, equipment and software to provide activity replanning, payload hardware performance assessment, fault isolation, and the assessment of scientific data. These design requirements allow the scientific flight crew to concentrate on scientific observations and on-the-spot decision making.

6.1.1 POCC equipment. The POCC will provide for historical storage of all payload data, formatting commands to the payload, voice communication with the Spacelab, scientific calculations and display of Spacelab TV. The number of consoles and other peripherals is (TBD). Table VI.I.I-1 is a summary of the POCC equipment functions and capability required for AMPS Flight 1.

Table VI.I.I-1. AMPS Flight 1 POCC Equipment Requirements

Equipment	Function	Capability Required
Front End Processor	Bit sync, decommutate position	1) 2.6 mbps
Data Storage	Hold data for access by computer system and remotes	1) Quick access (disk) 20 mbytes 2) Tape storage 80,000 mbytes
Computer System	Access data from data storage and MCC, develop displays, generate commands, perform scientific calculations, interrupt/prioritize	1) Interrogated by ≤ 10 peripherals
Consoles	Request and display data, assemble and transfer commands	1) Graphics 2) Refreshing 3) Partial update 4) Symbol generator

The responsibility for the development of these requirements rests with the AMPS integration contractor (AIC), recipients include the Shuttle Payloads Project office, JSC, MSFC and the Spacelab integration contractor.

6.1.2 POCC software. POCC software will be required to support the POCC functions previously described. The major software programs and their size are shown in Table VI.I.II-1.

Table VI.I.II-1. AMPS Flight 1 POCC Software Requirements

Software Program	Size (Words)	Developed	User
Operating System	(TBD)	GSFC	GSFC
Data Storage and Retrieval	100K	GSFC	GSFC
Display Generator	100K	GSFC	GSFC
Data Base	(TBD)	AIC	GSFC
Experiment Applications	(TBD)	(TBD)	GSFC
Planning	(TBD)	AIC	GSFC
Data Processing	(TBD)	GSFC	GSFC

6.2 POCC SUPPORT OPERATIONS FOR PAYLOAD INTEGRATION. The POCC will be configured to support the integration and test process. This will require data and voice interfaces with the experiment flight equipment during the mission operations systems test (MOST) and with the Orbiter during integrated systems test. The signal interfaces between the POCC and AMPS payload is described in Table VI.II-1.

Table VI.II-1. POCC/Payload Integration Data Interfaces

Integration Test	Uplink Digital		Downlink Data	
	Data	Command	Digital	Analog
Mission Operations Systems Test	(TBD)	(TBD)	(TBD)	(TBD)
Integrated Systems Test	1 mbps	8 kbps	50 mbps 2 mbps	4.2 MHz

6.3 POCC PERSONNEL SIMULATIONS/TRAINING REQUIREMENTS. Training for personnel assigned to AMPS Flight 1 will consist of involvement in the payload design, flight and experiment planning, and several flight simulations. The total training requirement is (TBD). At a minimum, the POCC crew should participate in the mission operations systems tests; interacting with the flight crew, data and planned procedures.

7. FLIGHT CREW REQUIREMENTS

7.1 CREW SIZE. The size and functions of the flight crew required to perform the requirements of this flight are shown in Table VII.I-1.

Table VII.I-1. Flight Crew Requirements

Flight Crew Functions	CDR	Pilot	Mission Spec	Payload Spec	Payload Spec
<u>Orbiter Flight Operations</u>					
Vehicle flight control	P	B			
Guidance, navigation	P	B			
Vehicle systems management	P	B			
Monitor, control flight safety items	P	B			
Consumables management	P	B	S		
Monitor caution and warning	P	B			
Electrical power management	P	B			
Environmental control	P	B			
<u>Payload Operations Management</u>					
Orbiter/payload subsystem checkout, operation			P		
Monitor payload caution and warning			P		
Manage payload support communications			P		
Activity scheduling	S	S	P	S	S
<u>Experiment Operations</u>					
Electron accelerator			S	P	B
Small instrument pointing				P	B
OBIPS			S	P	B
Vector magnetometer			S	P	B
Gas canister release	S	S		B	P
Optical instruments				P	P
IR radiometer				B	P
IR interferometer spectrometer				B	P
LIDAR				B	P
Environmental sensing package			S	P	P
Solar flux monitor				S	P
Remote manipulator			P		

P - Primary function

B - Back-up function

S - Support function

7.2 PAYLOAD SPECIALIST QUALIFICATIONS. The payload specialist is responsible for the attainment of experiment objectives. In this role, he is responsible for the management of the payload operations, proficient in experiment performance and knowledgeable in the operation of the caution and warning systems, hatches, tunnel and life support systems. In addition to these general characteristics, the payload specialists for each AMPS flight will have specific scientific training and experience. Each payload specialist should be an experimental physicist, one with a background in accelerators and the other in atmospheric physics.

- 7.3 AMPS TRAINING REQUIREMENTS. Payload specialist training is required for the activities shown in Table VII.III-1. The allocation of responsibility between GSFC and JSC is also defined.

Table VII.III-1. Payload Specialist Training Requirements

Requirement	Responsibility	
	GSFC	JSC
Certification for flight		X
Procedural training on experiments	X	
Experiment/Spacelab interface training	X	X
Combined experiments training	X	
Habitability and safety training		X
Integrated operations training		X

- 7.4 TRAINING EQUIPMENT REQUIREMENTS. The equipment required to accomplish the AMPS training plan has been selected to maximize the multiple use of AMPS or other existing equipment. A summary of the factors and applications of the selected equipment is shown in Figure 7.4-1. The training program can be accomplished using the following equipment:

- (1) Instrument development breadboards
- (2) Combined AMPS workstation mockup and payload simulator
- (3) AMPS integration facility
- (4) Spacelab/Orbiter trainer.

TRAINING EQUIPMENT	TRAINING APPLICATIONS	NEGATIVE FACTORS
● INSTRUMENT DEVELOPMENT BREADBOARDS AND SIMULATIONS	● INSTRUMENT PROCEDURES ● DATA TRENDS	● NOT "FLIGHT LIKE" ● LIMITED AVAILABILITY
● WORK STATION MOCK UP & PAYLOAD SIMULATOR	● EXPERIMENT PROCEDURES ● EXPERIMENT/SPACELAB INTERFACES ● INTEGRATED EXPERIMENT OPERATIONS ● SPACELAB FAMILIARIZATION	● LIMITED AVAILABILITY PRIOR TO LEVEL IV INTEGRATION
● AMPS INTEGRATION FACILITY	● PROCEDURES REFRESHER ● MISSION SIMULATION	● LIMITED INSTRUMENT OPERATION ● LIMITED AVAILABILITY ● INTERFERENCE WITH TESTING
● SPACELAB/ORBITER TRAINER (JSC)	● CDMS PROCEDURES ● SPACELAB FAMILIARIZATION ● INTEGRATED FLIGHT OPERATIONS	● LIMITED AVAILABILITY ● NO EXPERIMENT SIMULATION

Figure 7.4-1. AMPS Training Equipment Has Been Selected to Maximize Multiple Use of Hardware